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DARLINGTON NGS 'A'
EMERGENCY POWER GENERATOR #2
VIBRATION ACCEPTANCE TESTS

Report No 90-310-K

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ABSTRACT

As part of the Darlington NGS commissioning program, acceptance tests were carried out on Emergency Power Generator #2 to determine its vibration and dynamic characteristics. Casing velocity levels and/or shaft displacement levels were obtained on the AC generator, reduction gearbox, power turbine, gas producer and accessory gearbox at various loads. Vibration levels were also obtained during runup and rundown of the unit and were used to determine rotor critical speeds. Impact tests were performed to determine structural natural frequencies.

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EXECUTIVE SUMMARY

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
VIBRATION ACCEPTANCE TESTS

N. Jagan and P. Hoogendam
Plant Equipment Dynamics Section
Mechanical Research Department

As part of the Darlington NGS commissioning program, acceptance tests were carried out on Emergency Power Generator #2 to determine its vibration and dynamic characteristics.

The overall shaft displacement and bearing casing velocity levels measured on the AC generator, at various loads ranging from 0 MW to 6.8 MW, are considered acceptable. The overall velocity levels measured on the power turbine casing close to Bearing No 5 are very high. A structural natural frequency of the power turbine casing close to 30 Hz may be amplifying the vibration. The overall shaft displacement levels measured at the power turbine bearings are considered acceptable. The overall shaft displacement levels measured at the gas producer bearings are considered acceptable at all loads tested.

Structural dynamics testing indicates that the AC generator has a structural natural frequency at approximately 32 Hz which is just above its synchronous speed (30 Hz).

No rotor critical speeds of the AC generator were identified within the operating speed range (0 rpm to 1800 rpm). Rotor critical speeds of the power turbine were identified during runup and rundown at approximately 2750 rpm (46 Hz) and 3700 rpm (62 Hz). No other rotor critical speeds were identified below the power turbine synchronous speed of 8586 rpm. Rotor critical speeds of the gas producer were identified during runup and rundown at approximately 2400 rpm (40 Hz), 3400 rpm (57 Hz), 3900 rpm (65 Hz), 4950 rpm (83 Hz) and 5500 rpm (92 Hz). No other rotor critical speeds were identified below the gas producer speed of 8865 rpm.

It is recommended that velocity spectra should be periodically obtained on the AC generator bearing casings in the horizontal direction to trend the 30 Hz component. The manufacturer, Darlington Operations and Engineering, and Mechanical Research should discuss the feasibility of detuning the structural natural frequency of the AC generator close to its synchronous speed. The high vibration levels measured on the power turbine casing close to Bearing No 5 should be reduced. Detuning the structural natural frequency of the power turbine close to 30 Hz may reduce these levels.

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To Mr. D. McQuade
Technical Manager
Darlington NGS 'A'

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
VIBRATION ACCEPTANCE TESTS

1.0 INTRODUCTION

Vibration acceptance tests were carried out on the two emergency power generators EPG #1 and EPG #2, each rated at 6.8 MW, as part of the Darlington NGS 'A' commissioning program. This report discusses the results of the tests on EPG #2. Vibration data for EPG #1 can be found in reference 1.

The principal objectives of the tests were to:

1) Evaluate the acceptability of the machine vibration and dynamic characteristics with respect to specifications and/or industry standards.

2) Obtain baseline vibration data for use in future machine monitoring.

3) Make recommendations for corrective action if required.

The general turbine-generator arrangement is shown in Figures 1 and 2. The main components of the turbine-driven generator set (Solar Turbines) are the Mars industrial turbine engine, the Allen Gear speed-reducing epicyclical gear unit (4.76 gear ratio), and the Brush AC generator. The main components of the gas turbine engine are the compressor, the 2-stage gas producer and the 2-stage power turbine. A further description of the turbine-generator set is given in Appendix A.

The AC generator synchronous speed is 1800 rpm (30 Hz) and the power turbine synchronous speed is 8568 rpm (142.8 Hz). The speed of the gas producer varied from approximately 8865 rpm (147.8 Hz) to 10080 rpm (168 Hz) depending on load.

2.0 TEST PROGRAM, INSTRUMENTATION AND MEASUREMENTS

The test program for EPG #2 is outlined below :

1. The cold soaked unit was started and synchronized.

2. In order to evaluate the unit's vibration characteristics under different loads, the unit's power was increased from approximately 0 MW (synchronous idle) to the maximum load attainable (6.8 MW). Loads of 0 MW, 0.8 MW, 1.0 MW, 1.25 MW, 1.5 MW, 1.75 MW, 2.0 MW, 2.25 MW, 2.5 MW, 3 MW, 4 MW, 5 MW and 6.8 MW were selected.

The time elapsed between the cold start and the 6.8 MW load point was approximately 2 hours and 15 minutes.

3. The unit was maintained at 6.8 MW for an additional 2 hours before the load was reduced to 0 MW and the unit was rundown.

4. The unit was restarted (hot start), synchronized and then allowed to rundown.

5. Structural dynamics testing was carried out with the unit not running.

Vibration data was recorded on tape during periods of runup and rundown, and at each load setting.

Overall vibration velocity levels and spectra were obtained on the AC generator inboard and outboard bearing casings, on the reduction and accessory gear box casings, and on the power turbine casing (close to Bearing No 5). Velocity measurements were generally obtained in the vertical, horizontal, and axial directions. Overall shaft displacement levels and spectra were obtained at the bearing locations shown in Figure 1. Displacement measurements were taken in both the horizontal and vertical directions.

During runup and rundown of the unit, velocity and shaft displacement magnitude and phase at filtered 1 x shaft rotating frequency, versus shaft speed were plotted (Bode plot).

The test instrumentation and measurements are presented in Appendix J.

3.0 ALARM AND SHUTDOWN VIBRATION LIMITS

The alarm and shutdown limits (based on overall levels) specified for the emergency power generator /2/ are as follows.

	Alarm	Shutdown
AC Generator Bearing Casing Velocity (mm/s)	5.1	6.4
Reduction Gear Box Casing Velocity (mm/s)	9.0	12.0
Accessory Gear Box Casing Velocity (mm/s)	13.0	20.0
Power Turbine Shaft Displacement (μm p-p) (Bearings No 4 and No 5)	64.0	100.0
Gas Producer Shaft Displacement (μm p-p)		
- Bearing No 1	64	100.0
- Bearing No 2	64	89.0
- Bearing No 3	64	100.0

4.0 RESULTS AND DISCUSSION

Provided in this section are the casing and shaft vibration levels measured on the various components of the power generator. Bode plots obtained during runup and rundown are presented. Structural and rotor natural frequencies, identified from impact spectra and bode plots, are also presented.

4.1 Casing Overall Velocity Levels and Velocity Spectra

The casing velocity measurements obtained during the tests are presented below in the following sections :

Section 4.1.1	AC Generator Casing Vibration
Section 4.1.2	Reduction Gearbox Casing Vibration
Section 4.1.3	Power Turbine Casing Vibration
Section 4.1.4	Accessory Gearbox Casing Vibration

4.1.1 AC Generator Casing Vibration

The overall velocity levels measured at the AC generator bearing casings at the various loads are shown in Tables 2 and 3. The maximum overall velocity levels (horizontal and vertical directions) are:

	Maximum Overall Velocity (mm/s)		Percent of Alarm Level
	RMS Level	Peak Level	
Outboard Bearing Casing	0.9	2.0	39
Inboard Bearing Casing	1.4	2.9	57

These levels are acceptable. According to the Darlington NGS tendering document, for acceptance purposes the maximum lateral vibration measured on the bearing housings should not exceed 2.8 mm/s RMS.

Higher velocity levels were measured in the axial direction with the predominant component being at 60 Hz (2 x synchronous frequency) and may be indicative of misalignment. At the higher loads (> 4 MW) the 60 Hz component is significantly less than at the lower loads (Table 3). Since the vibration data at the lower loads were taken much earlier in the test, full thermal alignment may not have occurred.

Velocity spectra obtained at the AC generator bearing casing for the various loads are shown in Appendix B, Figures B1 - B40. These spectra show that the main frequency components are generally at 1 x and 2 x synchronous frequency. The vibration amplitudes at these frequencies are shown in Tables 2 and 3.

Subsynchronous vibration, at a frequency varying between 26.75 Hz and 28.5 Hz depending on load (frequency increasing with load), was also present at the loads up to and including 2.0 MW. At a load between 2.0 MW and 2.25 MW the subsynchronous frequency was no longer evident. Table 4 shows the amplitude of the subsynchronous and 1 x synchronous vibration, measured on the AC generator bearing casings, at various loads. The maximum amplitude of the subsynchronous vibration measured was 0.6 mm/s.

A discussion of this subsynchronous vibration will follow in Section 5.

4.1.2 Reduction Gearbox Casing Vibration

The overall velocity levels measured on the reduction gearbox (RGB) casing at various loads are summarized in Table 5. The maximum overall velocities are :

	Maximum Overall Velocity (mm/s)		Percent of Alarm Level
	RMS Level	Peak Level	
RGB Casing	3.1	6.8	76

These levels are considered to be acceptable given that the EPG operates for relatively short durations.

Velocity spectra obtained on the RGB casing at the various loads are shown in Appendix C, Figures C1 - C24. The spectra show that the main vibration component is at the power turbine synchronous frequency (143 Hz). The velocity levels at this frequency are given in Table 5. The spectra also show a frequency component at 75.8 Hz corresponding to the speed of the star gear of the epicyclic gear set.

The subsynchronous vibration, mentioned in Section 4.1.1 was also present on the RGB casing. Table 6 shows the magnitudes of the subsynchronous vibration. The maximum amplitude measured was 1 mm/s.

4.1.3 Power Turbine Casing Vibration

The overall velocity levels measured on the power turbine (PT) casing close to Bearing No 5 (Figure 2) at the various loads are shown in Table 7. The maximum overall velocity levels are :

	Maximum Overall Velocity (mm/s)	
	RMS Level	Peak Level
Power Turbine Casing	9.6	20.0

These levels are considered very high for turbomachinery bearing housing vibration and should be reduced.

Velocity spectra obtained on the power turbine bearing casing are shown in Appendix D, Figures D1 - D24. The spectra show that the main vibration components in the horizontal and vertical directions are at 143 Hz (power turbine synchronous speed), and at 30 Hz (AC generator synchronous speed) or at the sub-AC generator synchronous frequency (26.75 Hz to 28.5 Hz) depending on load. The velocity levels at 30 Hz and 143 Hz are given in Table 7. Table 8 shows the vibration level for the sub-AC generator synchronous component. Both the frequency and amplitude of the sub-AC generator synchronous vibration component increase with load. The maximum amplitude of the subsynchronous vibration is 4.63 mm/s (horizontal direction). At loads above 2.25 MW the subsynchronous frequency is no longer present. However, a significant increase in the amplitude of the 30 Hz component occurs. The 30 Hz component continues to increase with load attaining a maximum level of 10.6 mm/s in the horizontal direction at 6.8 MW. Figure 3 shows the velocity spectra with the 30 Hz and subsynchronous components versus load for the power turbine bearing casing (horizontal direction).

Impact spectra obtained at this location show a structural natural frequency at 33.5 Hz (Appendix I, Figure I13). This natural frequency would amplify the power turbine casing response at both the sub-AC generator synchronous and 30 Hz frequencies.

4.1.4 Accessory Gearbox Casing Vibration

The overall velocity levels measured on the accessory gearbox (AGB) casing at various loads are summarized in Table 9. The maximum overall velocity levels are :

	Maximum Overall Velocity (mm/s)		Percent of Alarm Level
	RMS Level	Peak Level	
RGB Casing	2.1	6.6	51

These levels are acceptable.

Velocity spectra obtained on the AGB casing at the various loads are shown in Appendix E, Figures E1 - E12.

4.2 Shaft Overall Displacement Levels and Displacement Spectra

The shaft displacement measurements obtained during the tests are presented below in the following sections :

Section 4.2.1	AC Generator Shaft Vibration
Section 4.2.2	Power Turbine Shaft Vibration
Section 4.2.3	Gas Producer Shaft Vibration

4.2.1 AC Generator Shaft Vibration

Overall shaft displacement levels measured at the inboard and outboard bearings of the AC generator at various loads are shown in Table 10. The maximum overall shaft displacement levels are:

	Maximum Overall Displacement (μm p-p)
Outboard Bearing	49
Inboard Bearing	41

These levels are acceptable. According to the Darlington NGS tendering document, for acceptance purposes the maximum shaft vibration should not exceed 60 μm p-p during operation.

Shaft displacement spectra obtained on the AC generator for the various loads are shown in Appendix B, Figures B41 - B72. These spectra show that the main vibration components are at the 1 x synchronous (30 Hz) and 2 x synchronous (60 Hz) frequencies. The displacement levels at 1 x and 2 x synchronous frequency are shown in Table 10. At low loads, the subsynchronous vibration observed on the AC generator bearing casing was also present in the shaft vibration. The amplitude of the subsynchronous shaft vibration is shown in Table 11 and did not exceed 6.1 μm p-p.

4.2.2 Power Turbine Shaft Vibration

Overall shaft displacement levels measured at Bearings No 4 and No 5 of the power turbine (PT) are presented in Table 12. The maximum overall shaft displacement levels are:

	Maximum Overall Displacement (μm p-p)	Percent of Alarm Level
Bearing No 4	15	24
Bearing No 5	25	39

These levels are acceptable.

Shaft displacement spectra obtained on the power turbine for the various loads are shown in Appendix D, Figures D25 - D56. These spectra show that the main vibration component is at the power turbine synchronous frequency (143 Hz). The displacement levels at 1 x and 2 x PT synchronous frequency are listed in Table 12. The sub-AC generator synchronous vibration was also present in the shaft displacement spectra at loads below 2.25 MW. The maximum sub-AC generator synchronous shaft displacement level measured was 3 μm p-p at Bearing No 4, and 7.5 μm p-p at Bearing No 5. The maximum shaft displacement measured at the 30 Hz frequency was 6.3 μm p-p at Bearing No 4 and 10.2 μm p-p at Bearing No 5.

4.2.3 Gas Producer Shaft Vibration

Overall shaft displacement levels measured at Bearings No 1, No 2 and No 3 of the gas producer (GP) are presented in Tables 13 and 14. The maximum overall shaft displacement levels are:

	Maximum Overall Displacement (μm p-p)	Percent of Alarm Level
Bearing No 1	15	24
Bearing No 2	21	33
Bearing No 3	8	13

These levels are acceptable.

Shaft displacement spectra obtained on the gas producer for the various loads are shown in Appendix F, Figures F1 - F48. These spectra show that the main vibration component is generally at the gas producer synchronous frequency. The gas producer synchronous speed varied with load from approximately 8865 rpm at no load to approximately 10080 rpm at full load (6.8 MW). The displacement levels at 1 x and 2 x GP synchronous frequency are listed in Tables 13 and 14.

There was no significant shaft vibration at the sub-AC generator synchronous frequency at any of the gas producer's bearings.

4.3 Cold Start Runup Bode Plots

1 x RPM filtered bode plots of the AC generator and power turbine casing velocity and shaft displacement levels obtained during the cold start runup are presented in Appendix G. Bode plots of the gas producer shaft

displacement levels also shown. Compensated and uncompensated bode plots are shown for the shaft displacement signals.

The maximum overall shaft displacement levels measured during the cold start runup are:

	Maximum Overall Displacement (μm p-p)
AC Generator Outboard Bearing	66
AC Generator Inboard Bearing	30
Gas Producer Bearing No 1	17
Gas Producer Bearing No 2	26
Gas Producer Bearing No 3	12
Power Turbine Bearing No 4	15
Power Turbine Bearing No 5	19

4.4 Hot Rundown Bode Plots

1 x RPM filtered bode plots of the AC generator and power turbine casing velocity and shaft displacement levels obtained during the hot rundown are presented in Appendix H. Bode plots of the gas producer shaft displacement levels are also shown.

The maximum overall and filtered (1 x RPM) shaft displacement levels measured during the hot rundown are:

	Maximum Displacement (μm p-p)	
	Overall	1 x Filtered
AC Generator Outboard Bearing	66	10
AC Generator Inboard Bearing	36	12
Gas Producer Bearing No 1	20	10
Gas Producer Bearing No 2	40	28
Gas Producer Bearing No 3	15	15
Power Turbine Bearing No 4	30	6
Power Turbine Bearing No 5	18	5

4.5 Rotor Natural Frequencies

The bode plots obtained during runup and rundown were used to identify the rotor natural frequencies (critical speeds) of the AC generator, power turbine and gas producer.

The bode plots obtained on the AC generator did not indicate any rotor natural frequencies of the AC generator within the speed range of zero to synchronous speed (1800 rpm). Since the first critical speed is above the speed range of the AC generator, it could not be identified from the vibration data. A theoretical rotor dynamic analysis would be necessary to determine the critical speeds of the AC generator. A theoretical rotor dynamic analysis, performed by Solar Turbines Incorporated /3/ indicates that the first critical speed of the AC generator may lie between 1900 rpm and 2200 rpm which is within 5.6 percent of the AC generator synchronous speed.

The critical speeds of the power turbine and gas producer that were identified from bode plots (Figures G12 - G21, Figures H12 - H21) are :

	Critical Speeds	Percent of Synchronous Speed
Power Turbine	- 2750 rpm (46 Hz)	32
	- 3700 rpm (62 Hz)	43
Gas Producer*	- 2400 rpm (40 Hz)	27
	- 3400 rpm (57 Hz)	38
	- 3900 rpm (65 Hz)	44
	- 4950 rpm (83 Hz)	56
	- 5500 rpm (92 Hz)	62

* Percent of GP Synchronous speed based on minimum speed measured of 8865 rpm.

No other rotor critical speeds of the power turbine or gas producer could be identified below their synchronous speeds.

4.6 Structural Natural Frequencies

4.6.1 AC Generator Structural Natural Frequencies

Impact spectra (compliance transfer functions) obtained on the AC generator casing are shown in Figures I3 to I9 (Appendix I).

Impact spectra obtained on the AC generator casing in the horizontal direction (Figures I4, I7, and I9) show a structural natural frequency at approximately 32 Hz. This structural natural frequency is very close to the synchronous speed (30 Hz) and will amplify the casing vibration. However, the filtered (1 x synchronous speed) velocity levels measured on the AC generator bearing casings (Tables 2 and 3) in the horizontal direction do not exceed 0.9 mm/s and are considered acceptable. Nevertheless, the vibration amplitude at the 30 Hz is dependent on the level of excitation at this frequency. Should this excitation increase in the future (possibly due to increased unbalance), amplification of the casing response by the structural natural frequency may result in unacceptable levels of vibration. In view of this, it is recommended that velocity spectra be periodically obtained at the AC generator bearing casings in the horizontal direction to obtain a trend of the 30 Hz vibration component.

Impact spectra obtained on the AC generator inboard casing also indicate a structural natural frequency at approximately 62 Hz (Appendix I, Figure I7) which is close to 2 x synchronous speed (60 Hz). From Table 3, the maximum vibration level at 2 x synchronous frequency measured at the inboard bearing casing was 1.6 mm/s (at 3 MW). At 6.8 MW, the 2 x synchronous vibration was 0.4 mm/s. These levels are considered acceptable. However, periodic monitoring of the AC generator casing vibration is recommended.

Impact spectra obtained on the AC generator casing in the axial direction show a structural natural frequency at approximately 30.5 Hz. However, the measured casing vibration levels in the axial direction are acceptable.

4.6.2 Reduction Gearbox Structural Natural Frequencies

Impact spectra obtained on the reduction gearbox casing are shown in Appendix I, Figures I10 and I11. Figure I11 shows a structural natural frequency at 62 Hz which is close to 2 x AC generator synchronous speed. However, the RGB casing vibration measured at the 60 Hz frequency is acceptable. Periodic monitoring of the RGB casing velocity levels is recommended.

4.6.3 Power Turbine Structural Natural Frequencies

Impact spectra (compliance transfer functions) obtained on the power turbine casing are shown in Figures I12 and I13 (Appendix I).

Impact spectra obtained on the power turbine casing close to Bearing No 5 show a structural natural frequency at approximately 33.75 Hz. This natural frequency is sufficiently close to the AC generator synchronous speed (30 Hz) and may be partially responsible for the high 30 Hz vibration measured on the power turbine casing close to Bearing No 5 (Table 7).

4.6.4 Gas Producer Structural Natural Frequencies

Impact spectra obtained on the gas producer casing in the vicinity of Bearing No 2 are shown in Figures I14 and I15. No structural natural frequencies close to the gas producer operating speed are evident.

5.0 SUBSYNCHRONOUS VIBRATION

As indicated in previous sections, a subsynchronous vibration component was present in the shaft displacement and casing velocity spectra obtained on the various components of the gas turbine (AC generator, reduction gearbox, power turbine, and gas producer). This subsynchronous component is present as soon as the gas turbine unit is loaded and remains until the load reaches approximately 2.25 MW. The frequency of this subsynchronous component is approximately 25.75 Hz when the unit is first loaded and increases with load. At a load between 2 MW and 2.25 MW, the subsynchronous frequency is no longer present. The subsynchronous component reappears during load reduction from 3 MW to 2 MW and remains until approximately zero load.

It appears that the subsynchronous component is in fact a sideband frequency resulting from a modulation of the 30 Hz component. A time plot of the inboard bearing shaft displacement (Figure 6) shows a modulation period of 0.367 seconds at 1 MW corresponding to a modulation frequency of 2.75 Hz. Modulation of the 30 Hz component results in a family of sideband equally spaced at 2.75 Hz around the 30 Hz component. This is shown in Figures 7, 8 and 9 for various measurement locations. The first sideband to the left of the 30 Hz component is the predominant 'subsynchronous' frequency at 27.25 Hz. At a higher load of 2 MW, the modulating period decreases to 0.533 seconds corresponding to a modulation frequency of approximately 1.875 Hz (Figure 10), and the sidebands are now spaced at 1.875 Hz (Figure 11).

During commissioning, the manufacturer (Solar Turbines) measured the dynamic vibration and lift (self centering) of the epicyclical reduction gear system as the load was increased. This data is shown in Figure 4 for the inner coupling, the outer coupling, and the ring gear of the epicyclical gear unit. Figure 5 shows a drawing of the reduction gear system. It has been the experience of the manufacturer that above some critical load the epicyclic components are properly meshed and the subsynchronous component is no longer present /4/. Figure 4 shows that the subsynchronous component is no longer present at loads above approximately 2.2 MW and marks the upper limit of the critical load range to centre the epicyclical components.

6.0 CONCLUSIONS

6.1 The overall shaft displacement and bearing casing velocity levels measured on the AC generator, at various loads ranging from 0 MW to 6.8 MW, are considered acceptable.

6.2 The overall velocity levels measured on the power turbine casing close to Bearing No 5 are considered unacceptable. The relatively high velocity levels are partially due to a high 30 Hz component at loads above 3 MW. A structural natural frequency of the power turbine casing close to 30 Hz may be amplifying the vibration.

6.3 The overall shaft displacement levels measured at the power turbine and gas producer bearings are considered acceptable at all loads tested.

6.4 Structural dynamics testing indicates that the AC generator has a structural natural frequency at approximately 32 Hz which is just above its synchronous speed (30 Hz).

The AC generator casing velocity levels measured are acceptable. However, increased levels of excitation at the synchronous frequency (most likely due to unbalance) combined with the possible amplification of the casing response by the structural natural frequency could result in unacceptable levels of vibration.

The AC generator also has a structural natural frequency in the axial direction at approximately 30.5 Hz.

6.5 The power turbine has a structural natural frequency at approximately 33.5 Hz which may be amplifying the casing response at 30 Hz.

6.6 The reduction gearbox casing has a structural natural frequency at approximately 62 Hz which is close to twice the AC generator synchronous speed. However, the vibration amplitude of the 60 Hz component, measured on the RGB casing, is acceptable.

6.7 Impact spectra obtained on the gas producer casing (power turbine end) do not show any structural natural frequencies close to the gas producer speed.

6.8 No rotor critical speeds of the AC generator were identified within the operating speed range (0 rpm to 1800 rpm).

6.9 Rotor critical speeds of the power turbine were identified at approximately 2750 rpm (46 Hz) and 3700 rpm (62 Hz). No other rotor critical speeds were identified below the power turbine synchronous speed of 8586 rpm.

6.10 Rotor critical speeds of the gas producer were identified at approximately 2400 rpm (40 Hz), 3400 rpm (57 Hz), 3900 rpm (65 Hz), 4950 rpm (83 Hz) and 5500 rpm (92 Hz). No other rotor critical speeds were identified below the gas producer speed of 8865 rpm.

7.0 RECOMMENDATIONS

7.1 Velocity spectra should be periodically obtained on the AC generator bearing casings in the horizontal direction to trend the 30 Hz component.

7.2 The manufacturer, Darlington Operations and Engineering, and Mechanical Research should discuss the feasibility of detuning the structural natural frequency of the AC generator close to its synchronous speed.

7.3 The manufacturer and the various engineering groups should discuss possible ways to reduce the high vibration levels measured on the power turbine casing close to Bearing No 5. Detuning a structural natural frequency of the power turbine close to 30 Hz may reduce these levels.

7.4 It is recommended that the reduction gearbox casing vibration be periodically monitored.

ACKNOWLEDGMENTS

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REFERENCES

1. N. Jagan, P. Hoogendam, "Darlington NGS 'A' Emergency Power Generator #1 - Vibration Acceptance Tests", Ontario Hydro Research Division Report No. 90-338-K, 1991.

2. Data supplied by Mr. K. Butt, Darlington NGS 'A' Operations.

3. D. Evans, "Torsional and Lateral System Dynamics Analysis of Mars Driven Brush generator for Ontario Hydro", Solar Turbines Incorporated, Report No. ER-2810, September 1984.

4. Private communication with Guill Cornejo, Solar Turbines Incorporated.

TABLE 1
INSTRUMENTATION LIST

1.	Accelerometer	Bruel & Kjaer Models 4368, 4384
2.	Displacement Transducer	Bently Nevada 7200 Series 5mm
3.	Charge Amplifier	Bruel & Kjaer Model 2635
4.	Displacement Transducer Amplifier	Ontario Hydro Research
5.	Dual Channel Analyzer	Ono Sokki CF 920
6.	Laserjet Printer	Texas Instruments - Omnilaser 2108
7.	Oscilloscope	Tektronix Model 2215
8.	Tape Recorder	Honeywell Model 101
9.	Tape Recorder	Hewlett Packard Model 3968A
10.	Filter	Krohn-Hite Model 3343
11.	Vibration Calibrator	Bruel & Kjaer Model 4294
12.	Digital Vector Filter	Bently Nevada DVF 3
13.	Instrumented Tip Impact Hammer	PCB Piezotronics Inc, Model 086B50
14.	Digital Plotter	Hewlett-Packard Model 7470A
15.	Photoelectric Tachometer Probe	Bruel & Kjaer MM 0024

TABLE 2

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
AC GENERATOR 1 x SYNCHRONOUS (30 Hz), 2 x SYNCHRONOUS AND OVERALL CASING VELOCITY LEVELS

	AC Generator Outboard Bearing Casing Velocity Vertical Direction				AC Generator Outboard Bearing Casing Velocity Horizontal Direction			
Load (MW)	1 x Sync (30 Hz) mm/s pk	2 x Sync (60 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (30 Hz) mm/s pk	2 x Sync (60 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.19	0.14	0.24	0.69	0.14	0.26	0.45	0.7-1.9
1.0	0.22	0.26	0.35	0.96	0.30	0.20	0.53	1.1-1.4
1.5	0.21	0.51	0.47	1.10	0.17	0.51	0.65	1.2-1.9
2.0	0.21	0.53	0.48	1.10	0.22	0.68	0.86	1.5-2.0
3.0	0.16	0.47	0.43	1.10	0.12	0.90	0.82	1.8-2.0
4.0	0.18	0.32	0.31	0.83	0.24	0.08	0.60	1.4-1.6
5.0	0.16	0.23	0.27	0.65	0.50	0.21	0.64	1.5-1.8
6.8	0.14	0.23	0.27	0.74	0.85	0.22	0.84	2.0

TABLE 3

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
AC GENERATOR 1 x SYNCHRONOUS (30 Hz), 2 x SYNCHRONOUS AND OVERALL CASING VELOCITY LEVELS

	AC Generator Inboard Bearing Casing Velocity Vertical Direction				AC Generator Inboard Bearing Casing Velocity Horizontal Direction				AC Generator Inboard Bearing Casing Velocity Axial Direction			
Load (MW)	1 x Sync (30 Hz) mm/s pk	2 x Sync (60 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (30 Hz) mm/s pk	2 x Sync (60 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	1 x Sync (30 Hz) mm/s pk	2 x Sync (60 Hz) mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.22	0.37	0.38	1.0	0.46	0.46	0.6-0.7	1.4-1.5	0.38	1.52	1.0-1.1	2.4-2.6
1.0	0.21	1.03	0.87	1.5-1.8	0.61	0.53	0.8-0.9	1.8-2.3	0.36	2.47	1.8-1.9	3.7-4.0
1.5	0.16	1.82	1.40	2.1-2.5	0.44	1.08	1.0-1.1	1.9-2.3	0.30	3.86	2.8-2.9	4.6-4.8
2.0	0.14	1.83	1.38	2.2-2.5	0.25	1.35	1.1-1.3	2.2-2.8	0.25	3.92	2.8-2.9	4.3-4.9
3.0	0.07	1.56	1.16	2.0-2.4	0.42	1.60	1.3	2.6-2.9	0.18	3.27	2.3-2.5	3.7-4.0
4.0	0.11	0.55	0.60	1.0-1.3	0.33	0.39	0.7	1.7-1.9	0.17	1.23	0.9-1.0	2.1-2.3
5.0	0.13	0.30	0.36	0.9-1.1	0.36	0.42	0.7	0.9-1.0	0.15	1.23	1.0-1.1	2.2-2.4
6.8	0.17	0.29	0.38	1.0	0.68	0.41	0.8	1.0	0.19	1.22	1.0-1.1	2.1-2.4

TABLE 4

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
AC GENERATOR 1 x SYNCHRONOUS (30 Hz) AND SUBSYNCHRONOUS CASING VELOCITY LEVELS

		Outboard Bearing Casing Velocity				Inboard Bearing Casing Velocity			
		Vertical Direction		Horizontal Direction		Vertical Direction		Horizontal Direction	
Load (MW)	Subsynchronous Frequency (Hz)	Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)	Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)	Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)	Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)
0.8	26.75	0.03	0.20	0.19	0.27	0.05	0.21	0.16	0.64
1.0	27.25	0.03	0.22	0.49	0.30	0.07	0.21	0.36	0.61
1.25	27.50	0.02	0.22	0.48	0.22	0.09	0.18	0.41	0.57
1.50	27.50	0.02	0.21	0.44	0.17	0.10	0.16	0.38	0.44
1.75	27.75	0.03	0.21	0.44	0.19	0.09	0.14	0.36	0.34
2.0	28.00	0.03	0.21	0.60	0.22	0.12	0.14	0.51	0.25
2.25	Sync	-	0.16	-	0.06	-	0.08	-	0.49
2.5	Sync	-	0.15	-	0.07	-	0.07	-	0.48
3.0	Sync	-	0.16	-	0.12	-	0.07	-	0.42
4.0	Sync	-	0.18	-	0.24	-	0.11	-	0.33
5.0	Sync	-	0.16	-	0.50	-	0.13	-	0.36
6.8	Sync	-	0.14	-	0.85	-	0.17	-	0.68

TABLE 5

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2 REDUCTION GEARBOX (RGB) CASING VELOCITY LEVELS

Load (MW)	RGB Casing Velocity Vertical Direction			RGB Casing Velocity Horizontal Direction			RGB Casing Velocity Axial Direction		
	143 Hz Component mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	143 Hz Component mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	143 Hz Component mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.68	0.9-1.1	1.6-2.3	1.24	1.3-1.6	2.2-4.0	1.23	1.0-1.3	1.4-3.4
1.0	0.44	1.2	1.8-3.0	1.83	1.9-2.2	3.6-4.7	1.68	1.7-2.0	2.7-4.5
1.5	0.63	0.8-1.0	1.5-3.0	2.63	2.3-2.5	4.1-5.3	2.59	2.3-2.6	2.6-5.7
2.0	0.75	1.0-1.1	1.4-2.6	2.87	2.4-2.7	3.9-7.0	2.82	2.6-2.8	4.0-5.7
3.0	0.76	0.8-0.9	1.6-2.0	3.29	2.7	4.0-5.0	3.26	2.8	4.3-6.0
4.0	0.93	0.9	1.5-2.1	3.61	3.0	3.9-5.7	3.66	3.0	4.0-6.1
5.0	0.99	0.9	1.7-1.9	3.70	3.1	3.6-6.3	3.79	3.1	4.2-6.8
6.8	0.97	1.0	1.7-2.0	3.52	2.9	4.5-6.2	3.67	2.6-3.0	5.0-6.8

TABLE 6

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
REDUCTION GEARBOX CASING VELOCITY LEVELS AT 30 HZ AND SUB-AC GENERATOR SYNCHRONOUS FREQUENCY

Load (MW)	Subsynchronous Frequency (Hz)	RGB Casing Velocity					
		Vertical Direction		Horizontal Direction		Axial Direction	
		Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)	Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)	Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)
0.8	26.75	0.21	0.16	0.54	0.30	0.39	0.37
1.0	27.25	0.48	0.14	1.10	0.22	0.65	0.34
1.25	27.50	0.36	0.15	1.15	0.34	0.51	0.25
1.50	27.50	0.31	0.11	0.90	0.27	0.40	0.18
1.75	27.75	0.35	0.11	1.00	0.27	0.40	0.13
2.0	28.00	0.38	0.11	1.00	0.28	0.45	0.12
2.25	Sync	-	0.26	-	0.65	-	0.30
2.5	Sync	-	0.23	-	0.60	-	0.36
3.0	Sync	-	0.23	-	0.57	-	0.41
4.0	Sync	-	0.22	-	0.37	-	0.46
5.0	Sync	-	0.24	-	0.29	-	0.49
6.8	Sync	-	0.25	-	0.26	-	0.53

TABLE 7

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
POWER TURBINE BEARING No 5 CASING VELOCITY LEVELS

Load (MW)	Brg No 5 Casing Velocity Vertical Direction				Brg No 5 Casing Velocity Horizontal Direction				Brg No 5 Casing Velocity Axial Direction			
	30 Hz Component mm/s pk	143 Hz Component mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	30 Hz Component mm/s pk	143 Hz Component mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk	30 Hz Component mm/s pk	143 Hz Component mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
0	0.19	4.28	3.9	5.6-10.5	0.59	4.43	3.8	6.0-9.2	0.1	1.16	0.8-1.4	3.0-5.5
1.0	0.22	4.02	4.2	7.0-10.0	0.90	3.88	3.8-4.1	7.2-10.7	0.1	1.35	3.9	6.9-8.5
1.5	0.22	4.08	4.1-4.3	6.1-9.9	0.80	3.72	3.8-4.2	6.3-8.8	0.1	1.48	4.0-4.2	4.6-6.3
2.0	0.37	4.86	4.2-4.5	7.2-10.2	1.40	4.13	4.2-5.0	8.9-13.0	0.1	1.66	2.6	5.4-6.2
3.0	5.61	5.41	6.6-7.2	11.0-14.7	8.63	4.45	7.8-8.4	13.0-17.0	0.7	1.83	2.8	3.8-7.3
4.0	6.58	5.71	7.0-7.4	12.0-16.3	10.30	5.14	8.2-9.0	14.5-16.0	1.0	1.68	3.6	7.2-8.5
5.0	6.74	5.72	7.1-7.4	14.5-18.5	10.60	5.41	8.6-9.6	14.0-20.0	1.1	1.50	4.5	8.0-10.8
6.8	6.08	5.42	7.7	15.0-17.5	10.60	5.42	8.8-9.5	13.0-18.2	1.0	1.16	3.1-3.4	5.6-8.0

Power Turbine Synchronous Speed - 143 Hz approximately
AC Generator Synchronous Speed - 30 Hz

TABLE 8

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
POWER TURBINE BEARING No 5 CASING VELOCITY LEVELS AT 30 Hz AND SUB-AC GENERATOR SYNCHRONOUS FREQUENCY

Load (MW)	Subsynchronous Frequency (Hz)	Brg No 5 Casing Velocity					
		Vertical Direction		Horizontal Direction		Axial Direction	
		Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)	Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)	Subsync Component (mm/s pk)	30 Hz Component (mm/s pk)
0.8	26.75	0.35	0.19	0.59	0.50	0.07	0.07
1.0	27.25	0.51	0.22	0.57	0.89	0.13	0.05
1.25	27.50	0.62	0.25	1.10	0.80	0.18	0.05
1.50	27.50	0.72	0.22	1.92	0.80	0.23	0.08
1.75	27.75	0.84	0.26	2.34	1.34	0.26	0.09
2.0	28.00	0.80	0.37	3.01	1.40	0.27	0.09
<2.25*	28.50	1.80	0.91	4.63	2.03	0.35	0.15
2.25	Sync	-	2.91	-	5.50	-	0.25
2.5	Sync	-	4.04	-	7.50	-	0.46
3.0	Sync	-	5.61	-	8.63	-	0.74
4.0	Sync	-	6.58	-	10.30	-	0.96
5.0	Sync	-	6.74	-	10.60	-	1.05
6.8	Sync	-	6.08	-	10.60	-	1.04

* Load between 2.0 MW and 2.25 MW

TABLE 9

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2 ACCESSORY GEARBOX (AGB) OVERALL CASING VELOCITY LEVELS

Load (MW)	AGB Casing Velocity Vertical Direction		AGB Casing Velocity Horizontal Direction	
	Overall RMS mm/s	Overall Peak mm/s pk	Overall RMS mm/s	Overall Peak mm/s pk
1.5	0.8	2.1-2.3	1.2	2.6-3.4
2.0	2.0	5.6-6.3	1.2	3.4-3.8
3.0	2.1	5.6-6.2	1.4	3.8-4.2
4.0	2.0	5.7-6.0	1.3	3.9-4.4
5.0	2.1	6.0-6.6	1.3	3.7-4.1
6.8	1.8	5.4-5.7	1.2	3.8-4.5

TABLE 10

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
AC GENERATOR 1 x SYNCHRONOUS (30 Hz), 2 x SYNCHRONOUS, AND OVERALL SHAFT DISPLACEMENT LEVELS

	AC Generator Outboard Bearing Shaft Displacement Vertical Direction (μm p-p)			AC Generator Outboard Bearing Shaft Displacement Horizontal Direction (μm p-p)			AC Generator Inboard Bearing Shaft Displacement Vertical Direction (μm p-p)			AC Generator Inboard Bearing Shaft Displacement Horizontal Direction (μm p-p)		
Load (MW)	1 x Sync (30 Hz)	2 x Sync (60 Hz)	Overall	1 x Sync (30 Hz)	2 x Sync (60 Hz)	Overall	1 x Sync (30 Hz)	2 x Sync (60 Hz)	Overall	1 x Sync (30 Hz)	2 x Sync (60 Hz)	Overall
0	20.3	27.2	44	23.2	25.0	47	5.8	9.0	20	9.4	11.1	25
1.0	18.7	26.8	44	22.0	23.7	46	5.7	8.4	21	9.6	13.5	29
1.5	17.0	27.7	42	20.4	21.0	42	6.1	6.7	20	12.1	19.1	37
2.0	15.5	28.2	43	20.0	19.9	40	7.6	6.0	18	13.2	22.0	41
3.0	14.2	29.1	44	20.3	24.5	44	7.4	2.0	17	14.9	18.9	37
4.0	14.3	27.0	42	21.1	26.2	46	7.6	7.7	20	13.8	8.5	27
5.0	14.0	26.7	40	22.4	24.9	46	8.4	8.6	21	13.7	11.4	28
6.8	13.3	26.6	40	23.7	25.1	49	9.3	8.7	22	13.9	11.2	27

TABLE 11

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
AC GENERATOR 1 x SYNCHRONOUS (30 Hz) AND SUBSYNCHRONOUS SHAFT DISPLACEMENT LEVELS

Load (MW)	Subsynchronous Frequency (Hz)	Outboard Bearing Shaft Displacement				Inboard Bearing Shaft Displacement			
		Vertical Direction		Horizontal Direction		Vertical Direction		Horizontal Direction	
		Subsync Component (μm p-p)	30 Hz Component (μm p-p)	Subsync Component (μm p-p)	30 Hz Component (μm p-p)	Subsync Component (μm p-p)	30 Hz Component (μm p-p)	Subsync Component (μm p-p)	30 Hz Component (μm p-p)
0.8	26.75	0.4	19.5	1.5	22.0	1.1	5.6	3.6	8.9
1.0	27.25	0.7	18.7	3.3	21.3	2.3	5.7	5.6	9.6
1.25	27.50	0.7	17.3	3.2	20.4	2.3	5.6	6.1	11.2
1.50	27.50	0.4	17.0	2.4	20.4	2.5	6.1	3.3	12.1
1.75	27.75	0.2	16.0	2.5	20.0	2.2	6.9	3.0	12.8
2.0	28.00	0.4	15.5	3.2	20.0	2.0	7.6	3.5	13.2
2.25	Sync	-	14.9	-	19.6	-	6.6	-	13.0
2.5	Sync	-	15.2	-	20.4	-	6.9	-	13.7
3.0	Sync	-	14.2	-	20.3	-	7.4	-	14.9
4.0	Sync	-	14.3	-	21.1	-	7.6	-	13.8
5.0	Sync	-	14.0	-	22.4	-	8.4	-	13.7
6.8	Sync	-	13.3	-	23.7	-	9.3	-	13.9

TABLE 12

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
POWER TURBINE 1 x SYNCHRONOUS (143 Hz), 2 x SYNCHRONOUS, AND OVERALL SHAFT DISPLACEMENT LEVELS

	Power Turbine Bearing No 4 Shaft Displacement Vertical Direction (μm p-p)			Power Turbine Bearing No 4 Shaft Displacement Horizontal Direction (μm p-p)			Power Turbine Bearing No 5 Shaft Displacement Vertical Direction (μm p-p)			Power Turbine Bearing No 5 Shaft Displacement Horizontal Direction (μm p-p)		
Load (MW)	1 x Sync	2 x Sync	Overall	1 x Sync	2 x Sync	Overall	1 x Sync	2 x Sync	Overall	1 x Sync	2 x Sync	Overall
0	4.3	0.4	8	4.2	0.8	10	7.3	1.7	11	8.3	3.1	14
1.0	4.0	0.4	10	3.9	0.6	8	7.2	2.2	15	8.1	3.5	16
1.5	3.9	0.5	9	3.5	0.6	8	7.5	2.6	16	8.3	3.7	20
2.0	3.5	0.5	10	3.4	0.5	10	8.5	2.7	16	9.1	3.6	20
3.0	3.1	0.4	14	3.6	0.6	11	9.3	2.8	20	9.6	3.5	20
4.0	3.1	0.6	9	3.6	0.5	14	9.5	3.3	22	10.4	4.0	20
5.0	3.4	0.6	12	3.7	0.5	10	9.6	3.5	25	10.7	3.6	21
6.8	4.1	0.7	15	3.9	0.4	13	9.0	3.5	23	10.5	3.3	20

TABLE 13

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
GAS PRODUCER 1 x SYNCHRONOUS*, 2 x SYNCHRONOUS, AND OVERALL SHAFT DISPLACEMENT LEVELS

	Gas Producer Bearing No 1 Shaft Displacement Vertical Direction (µm p-p)			Gas Producer Bearing No 1 Shaft Displacement Horizontal Direction (µm p-p)			Gas Producer Bearing No 2 Shaft Displacement Vertical Direction (µm p-p)			Gas Producer Bearing No 2 Shaft Displacement Horizontal Direction (µm p-p)		
Load (MW)	1 x Sync	2 x Sync	Overall	1 x Sync	2 x Sync	Overall	1 x Sync	2 x Sync	Overall	1 x Sync	2 x Sync	Overall
0	8.8	2.6	11	7.7	2.0	10	11.0	1.0	13	8.5	1.0	11
1.0	9.1	2.2	12	9.4	2.0	12	11.5	1.0	14	10.3	1.0	13
1.5	9.0	2.4	12	9.2	2.1	12	11.0	1.0	15	9.6	0.6	13
2.0	8.7	2.3	12	9.5	2.0	13	11.3	1.0	16	9.8	0.7	14
3.0	9.4	2.5	13	10.3	2.2	13	12.2	1.3	18	11.2	0.7	15
4.0	11.2	2.0	13	11.8	1.9	15	15.0	1.0	21	13.2	0.4	17
5.0	12.0	2.0	14	12.4	2.1	15	15.6	1.0	20	13.8	0.6	17
6.8	12.0	2.2	15	11.7	2.1	14	15.7	1.0	21	14.2	0.5	17

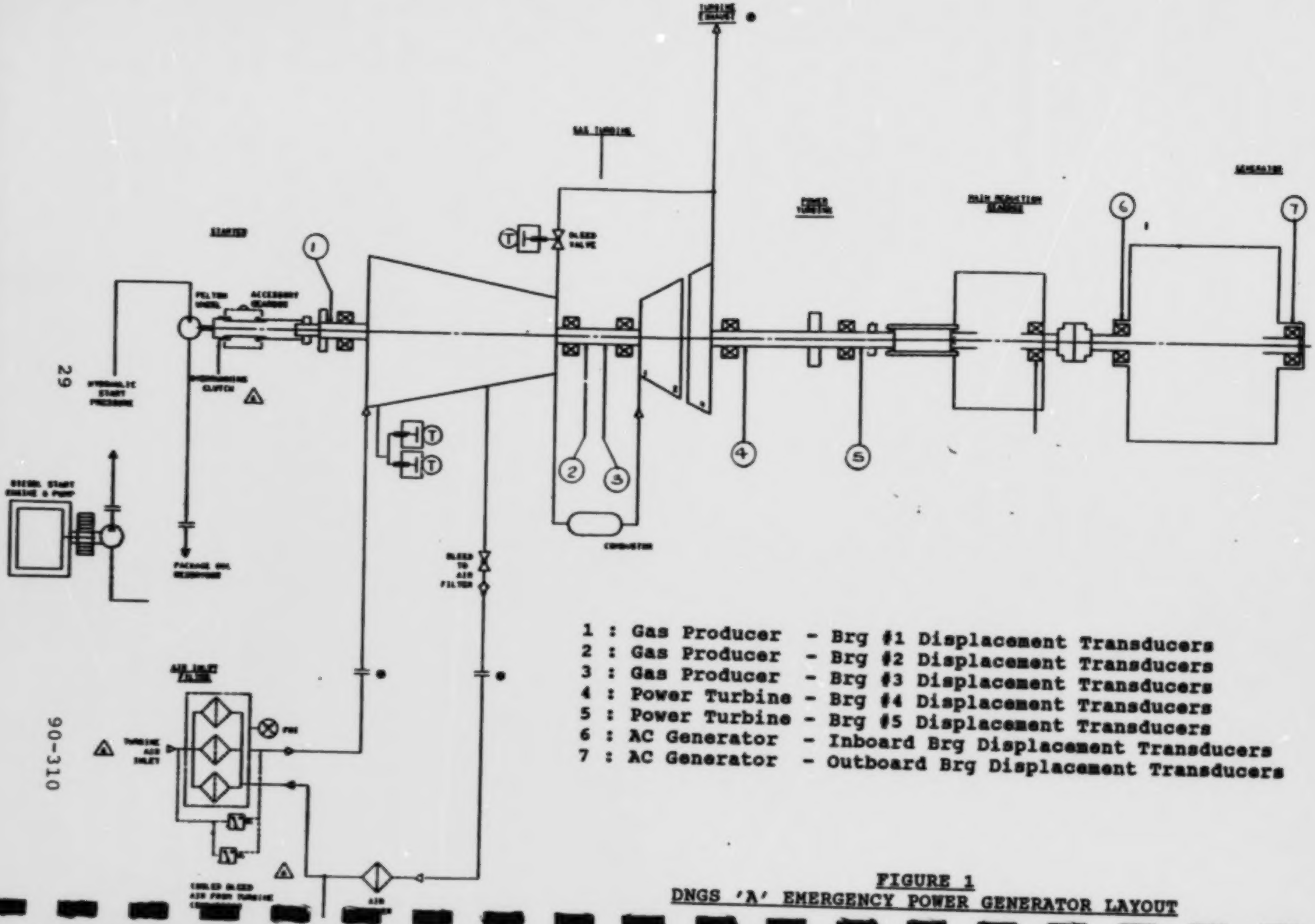
* Gas Generator Synchronous Speed = 8865 rpm (147.8 Hz) to 10080 rpm (168 Hz) depending on load

TABLE 14

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
GAS PRODUCER 1 x SYNCHRONOUS*, 2 x SYNCHRONOUS, AND OVERALL SHAFT DISPLACEMENT LEVELS

	Gas Producer Bearing No 3 Shaft Displacement Vertical Direction (μm p-p)			Gas Producer Bearing No 3 Shaft Displacement Horizontal Direction (μm p-p)		
Load (MW)	1 x Sync	2 x Sync	Overall	1 x Sync	2 x Sync	Overall
0	4.0	0.5	6	1.7	0.2	4
1.0	2.8	0.3	6	2.7	0.2	5
1.5	1.3	0.4	5	2.4	0.3	5
2.0	1.0	0.4	5	2.4	0.3	6
3.0	1.7	0.4	6	2.3	0.3	5
4.0	2.7	0.5	8	2.4	0.3	5
5.0	3.5	0.5	8	2.2	0.4	6
6.8	2.2	0.5	7	2.0	0.4	5

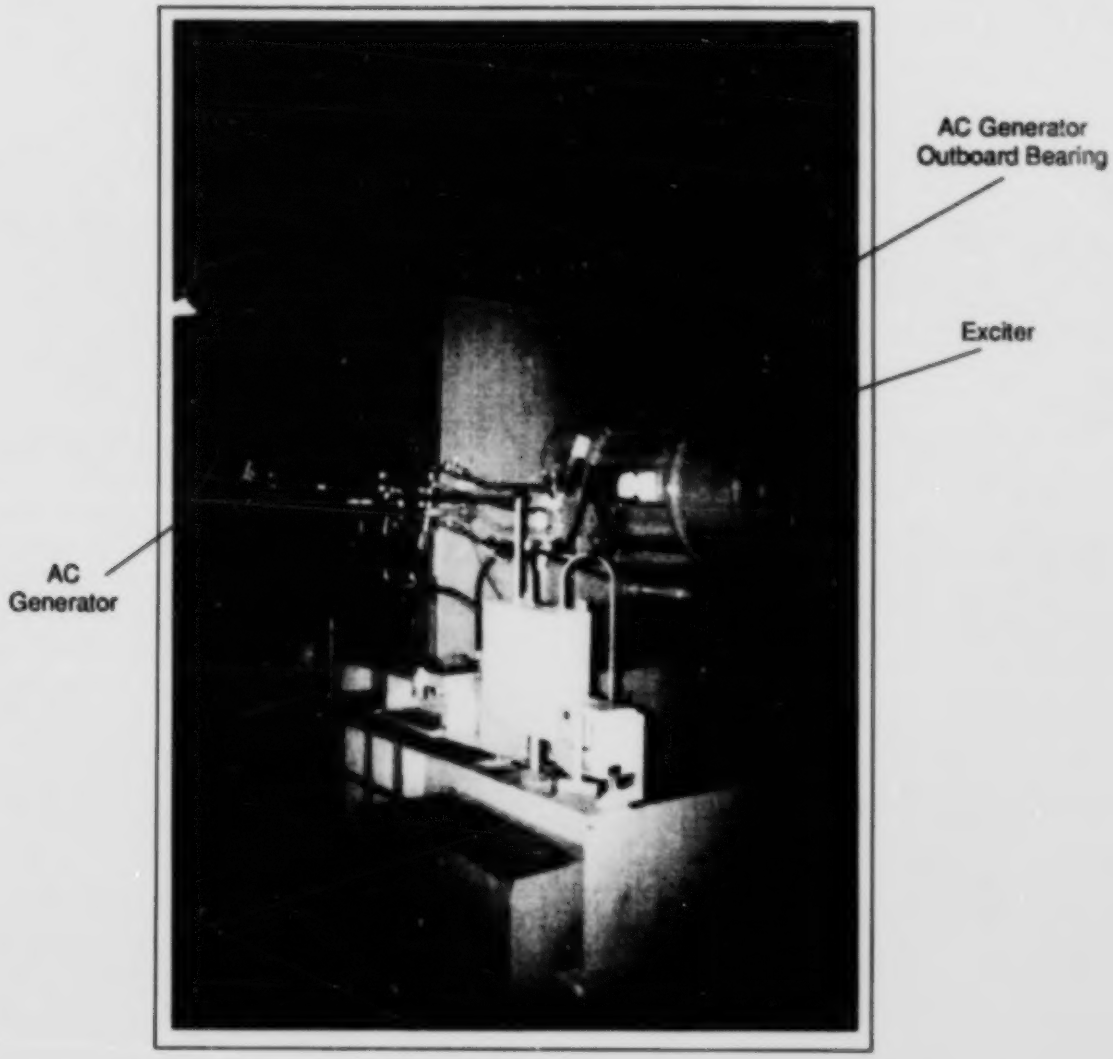
* Gas Generator Synchronous Speed - 8865 rpm (147.8 Hz) to 10080 rpm (168 Hz) depending on load



1
2
3
4
5
6
7
T
BLEED VALVE
ACCESSORY GEARBOX
CLUTCH
HYDRAULIC START PRESSURE
BLEED TO AIR FILTER

1 : Gas Producer - Brg #1 Displacement Transducers
2 : Gas Producer - Brg #2 Displacement Transducers
3 : Gas Producer - Brg #3 Displacement Transducers
4 : Power Turbine - Brg #4 Displacement Transducers
5 : Power Turbine - Brg #5 Displacement Transducers
6 : AC Generator - Inboard Brg Displacement Transducers
7 : AC Generator - Outboard Brg Displacement Transducers

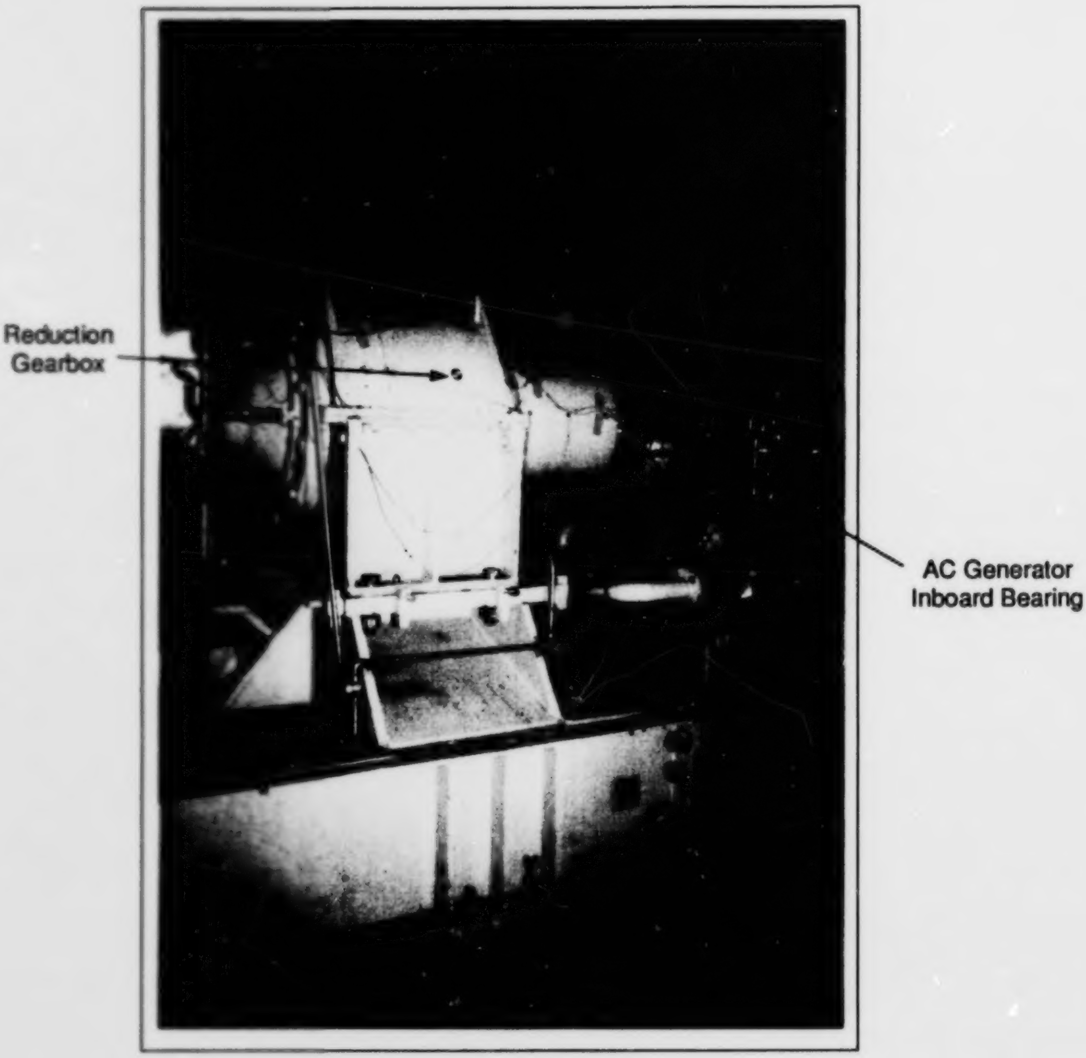
FIGURE 1
DNGS 'A' EMERGENCY POWER GENERATOR LAYOUT


AC Generator Outboard Bearing
Exciter
AC Generator

(a) AC Generator

FIGURE 2

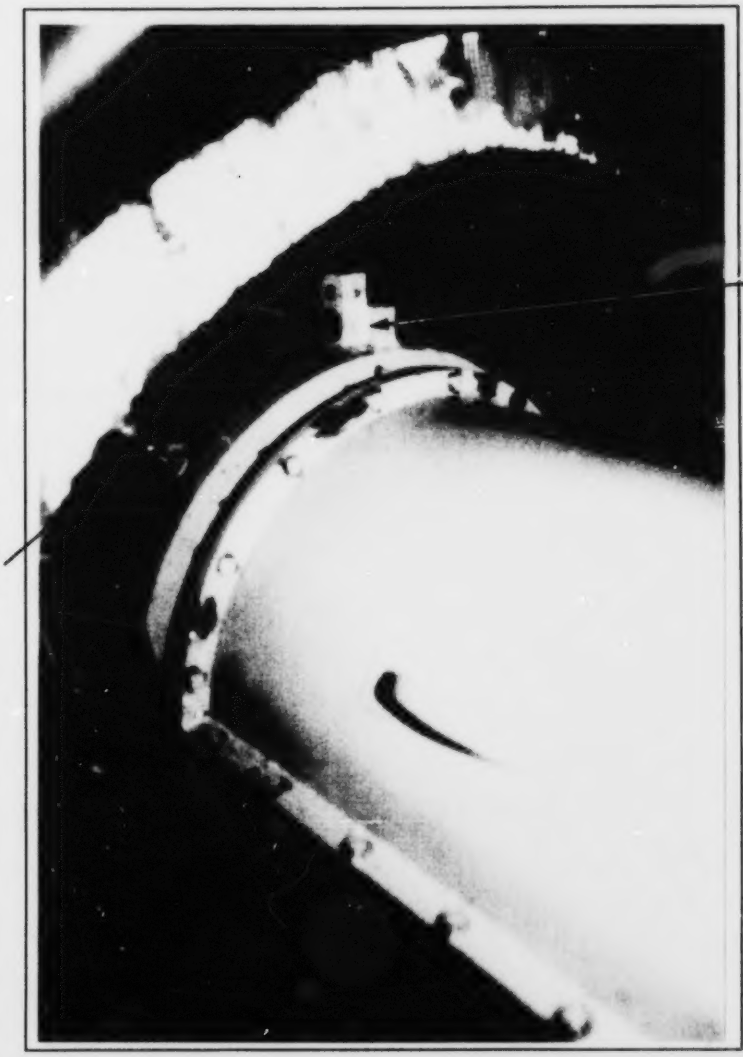
DNGS 'A' EMERGENCY POWER GENERATOR


Reduction Gearbox
AC Generator Inboard Bearing

(b) Reduction Gear Box

FIGURE 2

DNGS 'A' EMERGENCY POWER GENERATOR



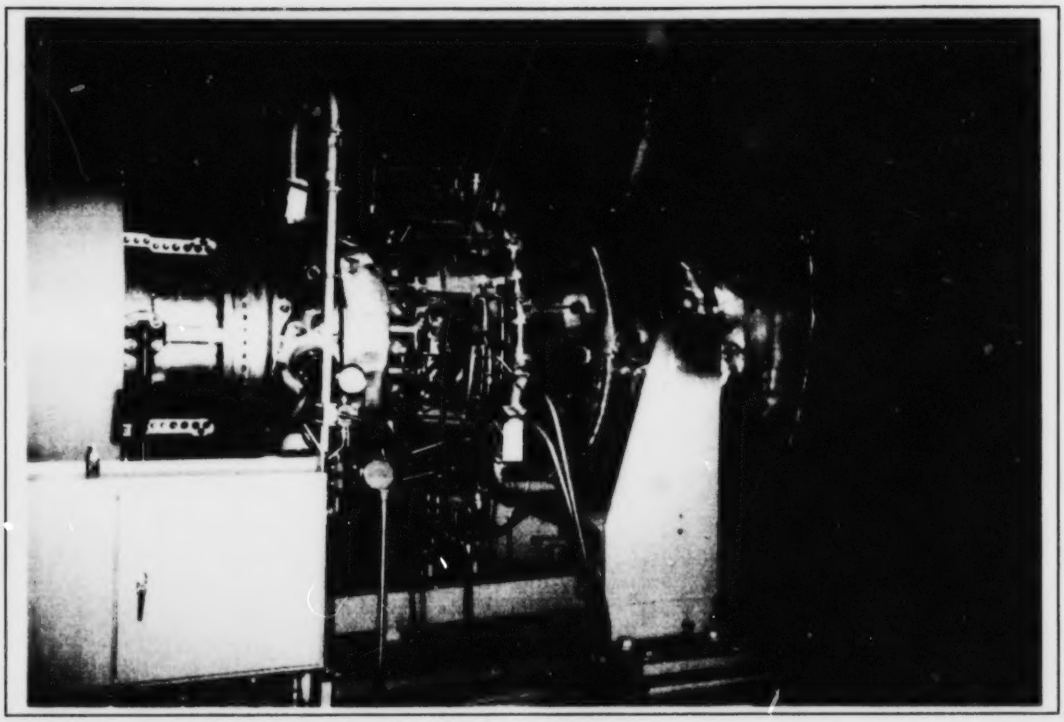
Location of Accelerometers on Power Turbine Casing

Power Turbine Bearing No. 5

(c) Power Turbine Casing Near Bearing No. 5

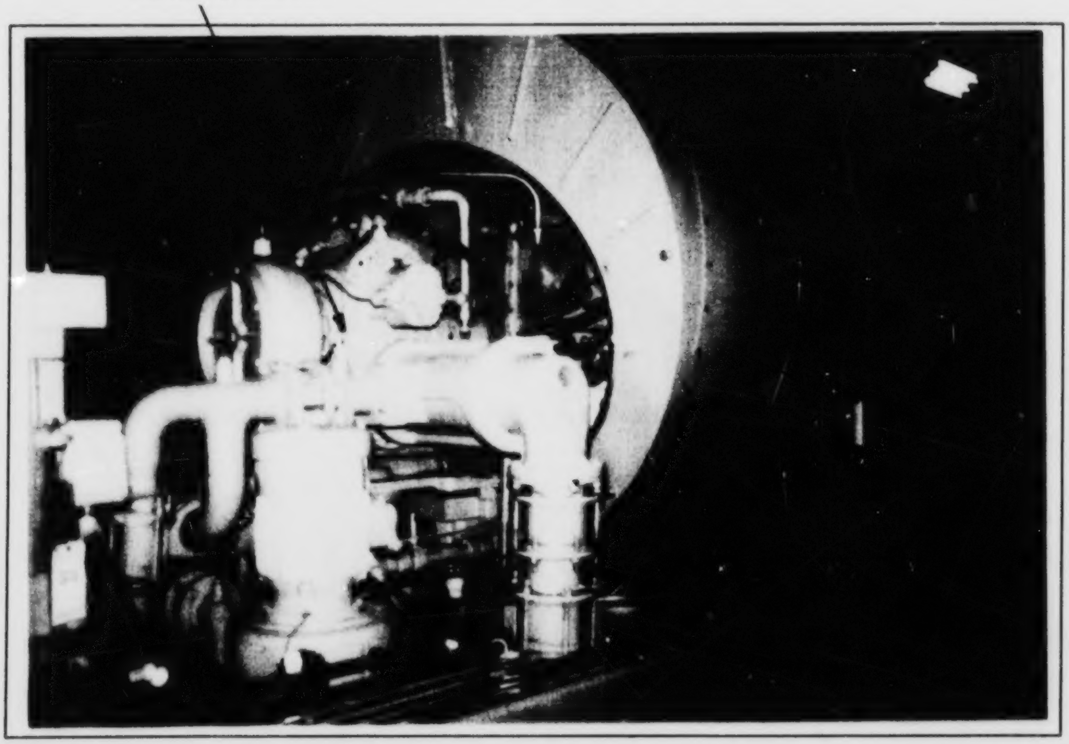
FIGURE 2

DNGS 'A' EMERGENCY POWER GENERATOR



(d) Gas Producer

Accessory Gearbox



(e) Accessory Gearbox

FIGURE 2

DNGS 'A' EMERGENCY POWER GENERATOR

90-310

184979-B27-RD

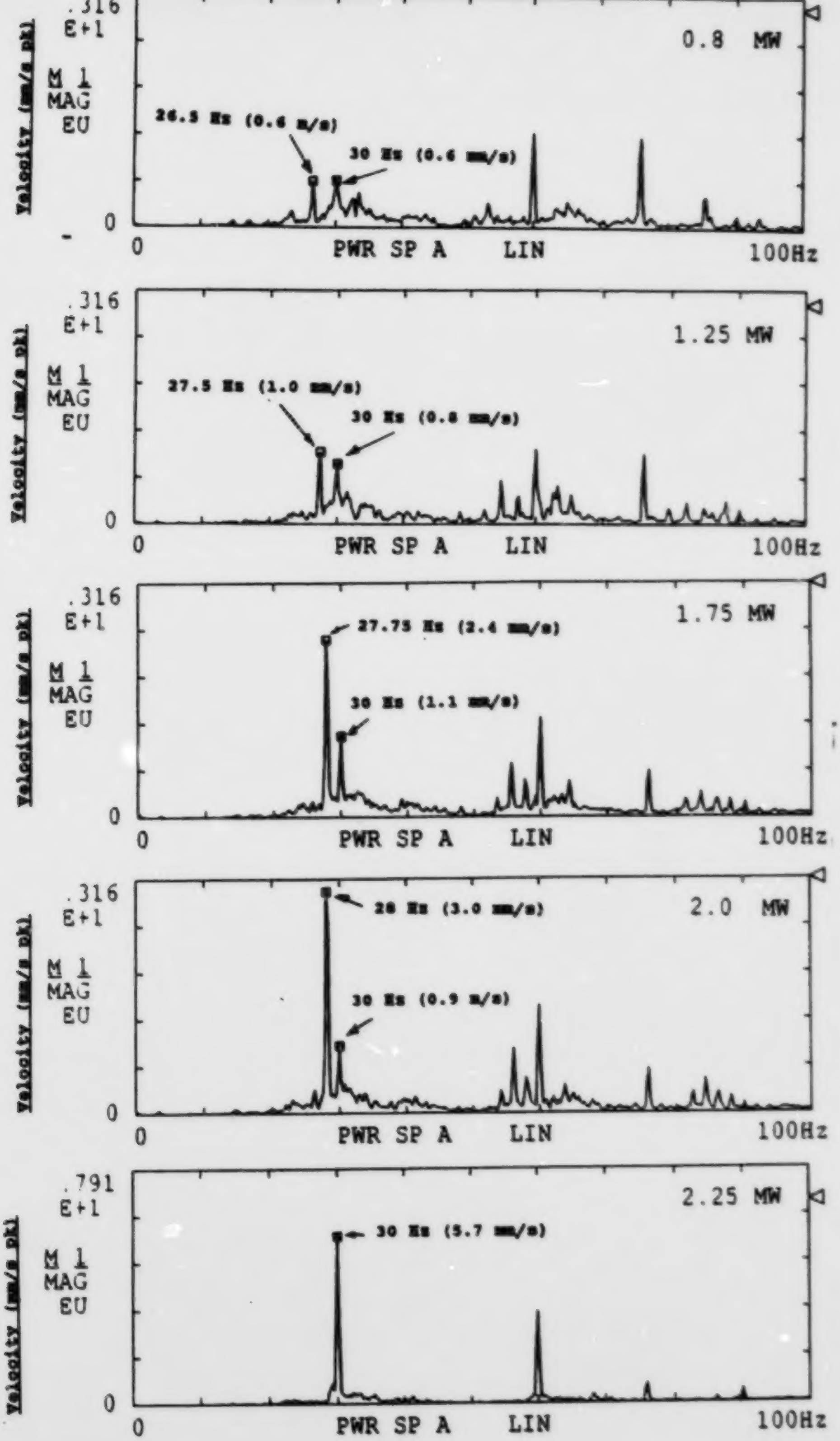


FIGURE 3

DNGS 'A' EPG#2 POWER TURBINE
BEARING NO 5 CASING VELOCITY SPECTRA (HORIZONTAL DIRECTION) VERSUS LOAD

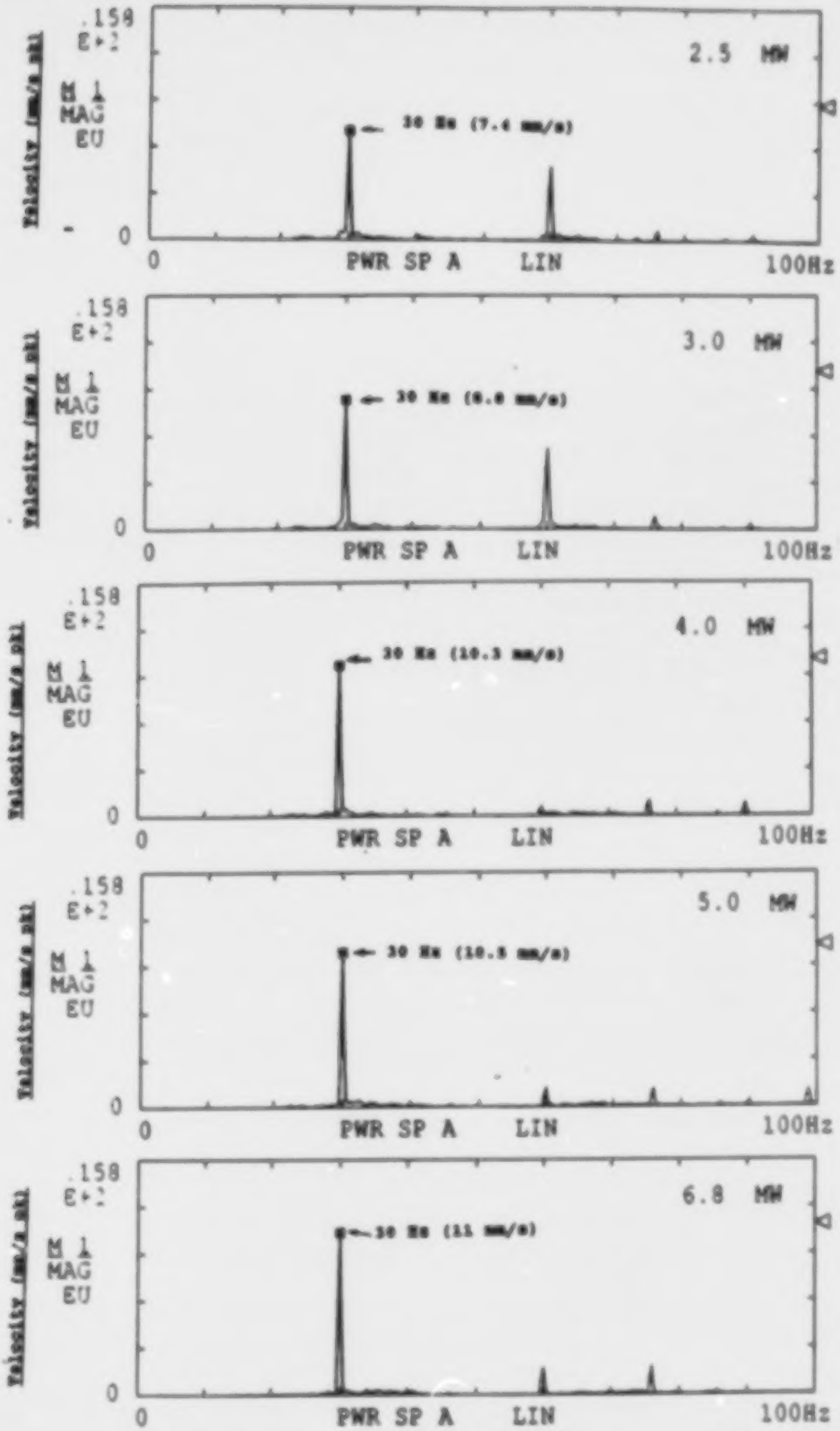


FIGURE 3 (cont'd)

DNGS 'A' EPG#2 POWER TURBINE
BEARING NO 5 CASING VELOCITY SPECTRA (HORIZONTAL DIRECTION) VERSUS LOAD

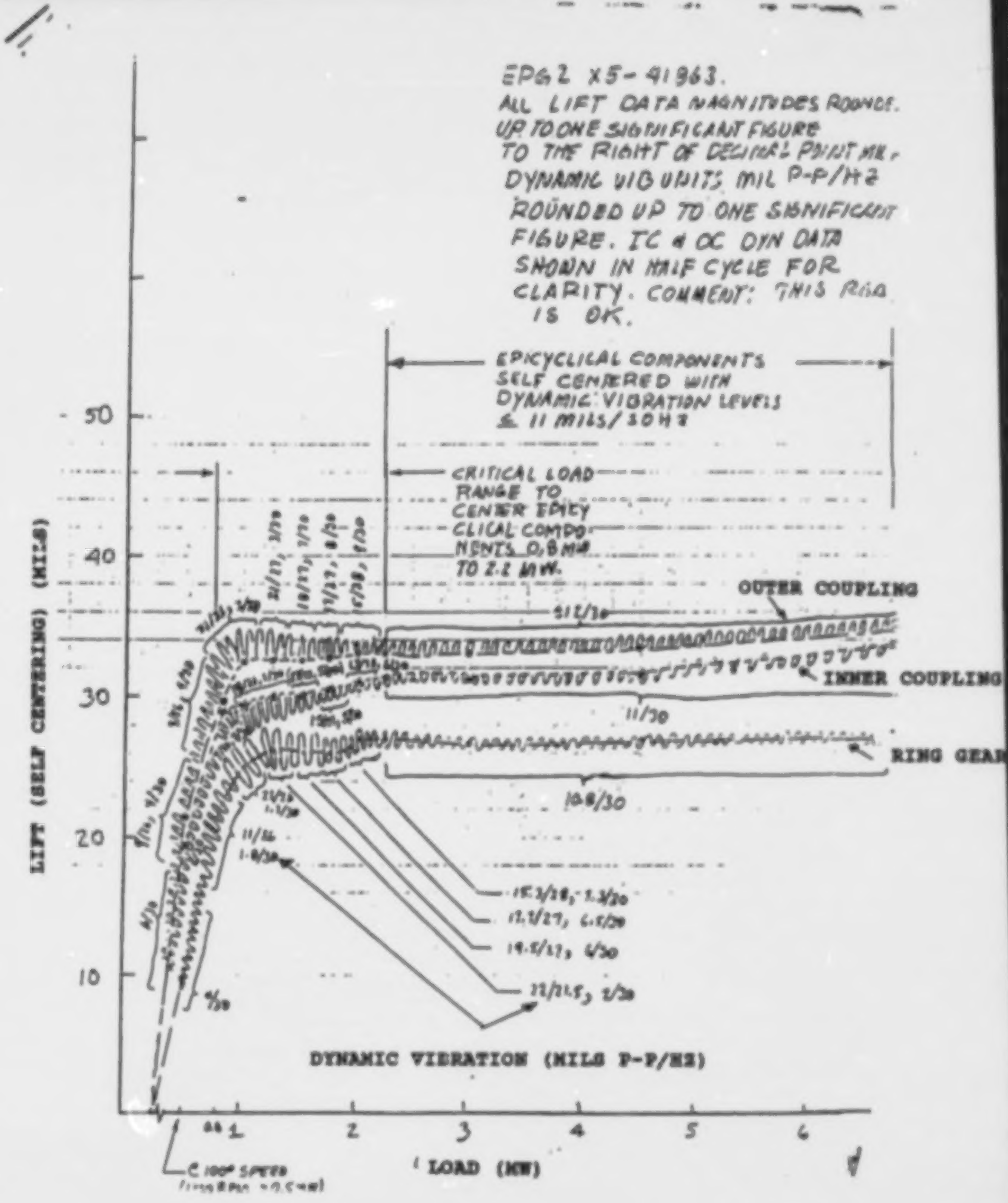

EPG2 X5-41963.
ALL LIFT DATA MAGNITUDES ROUNDED UP TO ONE SIGNIFICANT FIGURE TO THE RIGHT OF DECIMAL POINT MK.
DYNAMIC VIB UNITS MIL P-P/HZ ROUNDED UP TO ONE SIGNIFICANT FIGURE. IC & OC DYN DATA SHOWN IN HALF CYCLE FOR CLARITY. COMMENT: THIS RGA IS OK.

FIGURE 4

DYNAMIC VIBRATION AND LIFT VERSUS LOAD FOR EPG#2 REDUCTION GEAR SET

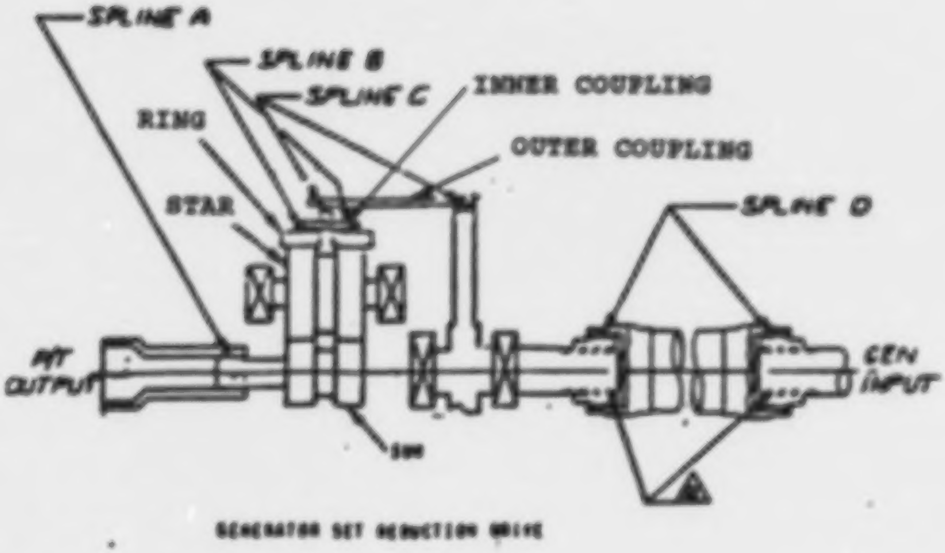

SPLINE A
SPLINE B
SPLINE C
INNER COUPLING
RING
OUTER COUPLING
STAR
SPLINE D
PT OUTPUT
GEN INPUT
SUN
GENERATOR SET REDUCTION DRIVE

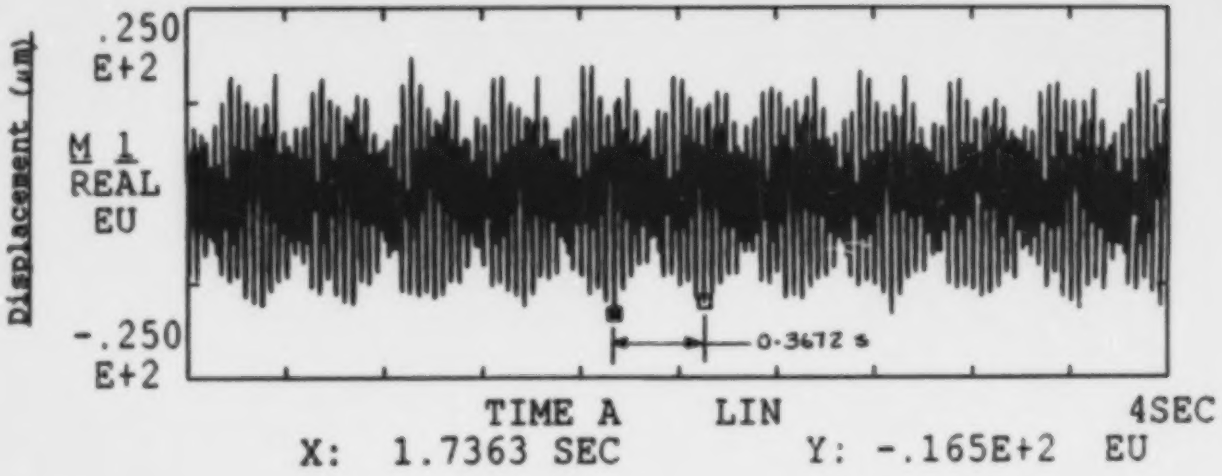
FIGURE 5

DNGS 'A' EPG #2
GENERATOR SET REDUCTION DRIVE

FIGURE 6

DNGS 'A' EPG#2 AC GENERATOR
INBOARD BEARING - SHAFT DISPLACEMENT (HORIZONTAL DIRECTION)
LOAD = 1.0 MW

```
           TIME   ChA
   1     1.7363 SEC      -.165E+2  EU
   2     2.1035          -.150E+2
   3
   4
   5
   6
   7
   8
   9
  10
```

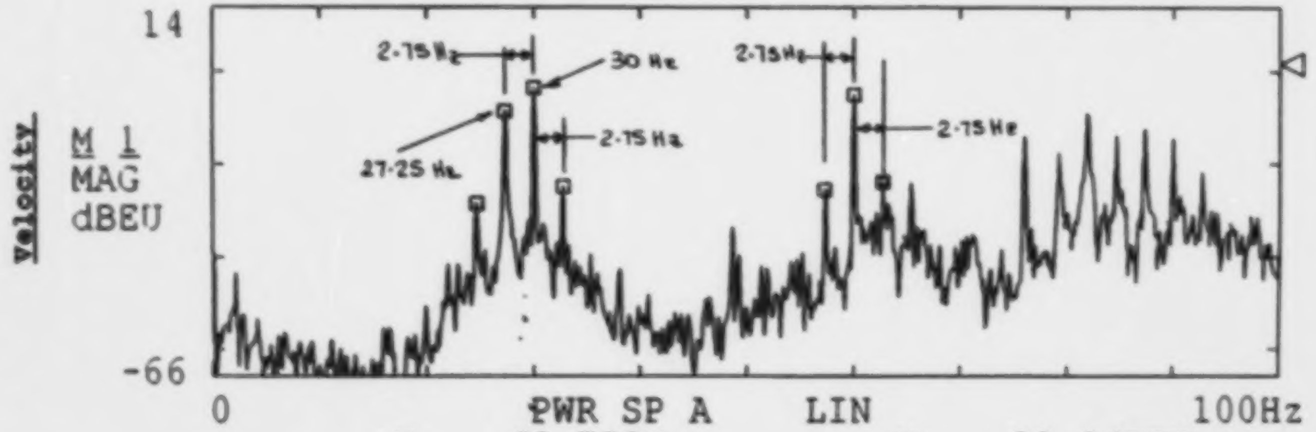


02:07

FIGURE 7

DNGS 'A' EPG#2 AC GENERATOR
INBOARD BEARING - SHAFT DISPLACEMENT SPECTRA (HORIZONTAL DIRECTION)
LOAD = 1.0 MW

```
           PWR SPECTRUM  ChA
     1     24.625Hz        -28.6dBEU   .373E-1  EU = (mm/s pk)
     2     27.250            -8.7      .368E+0
     3     30.000            -3.5      .666E+0
     4     32.750           -24.8      .576E-1
     5     57.250           -25.7      .521E-1
     6     60.000            -5.1      .554E+0
     7     62.750           -23.9      .640E-1
     8
     9
    10
```



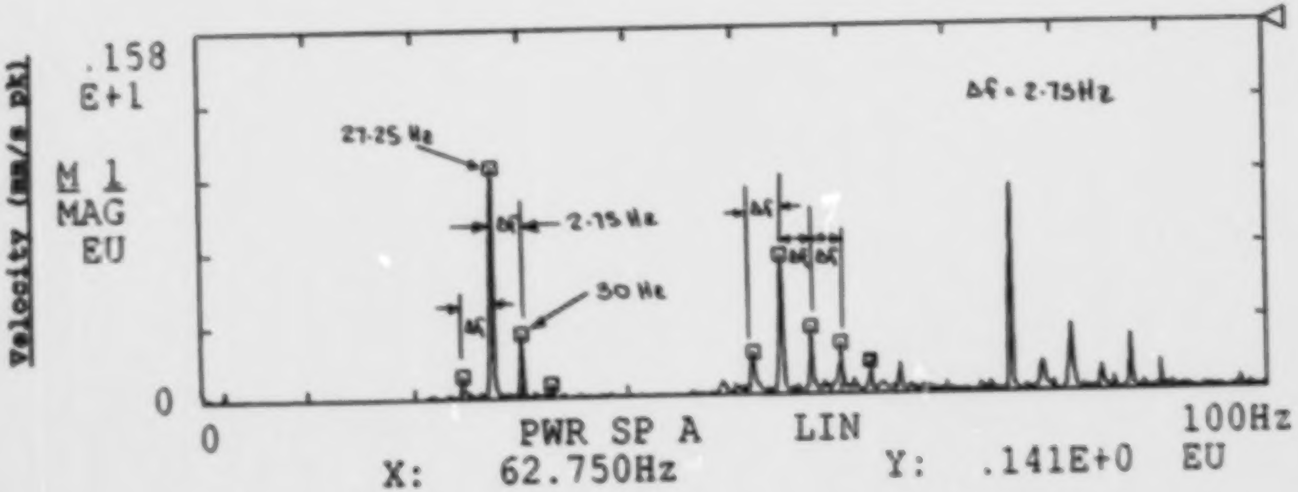
X: 62.750Hz Y: -23.9dBEU

02:13

FIGURE 8

DNGS 'A' EPG#2 REDUCTION GEARBOX
CASING VELOCITY SPECTRA (HORIZONTAL DIRECTION)
LOAD = 1.0 MW

	PWR SPECTRUM	ChA	
1	24.500Hz	.999E-1	EU
2	27.250	.997E+0	
3	30.000	.283E+0	
4	32.750	.639E-1	
5	51.750	.185E+0	
6	54.375	.602E+0	
7	57.250	.289E+0	
8	60.000	.219E+0	
9	62.750	.141E+0	
10			

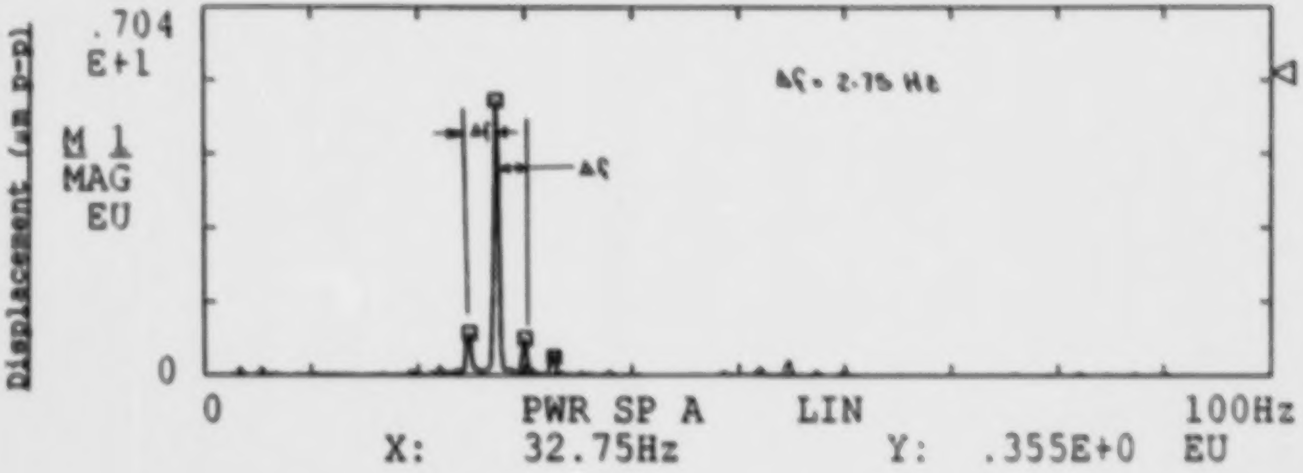


02:17

FIGURE 9

DNGS 'A' EPG#2 EPICYCLIC GEAR SET
OUTER COUPLING DISPLACEMENT SPECTRA
LOAD = 1.0 MW

```
        PWR SPECTRUM  ChA
 1       24.75Hz         .818E+0  EU
 2       27.25           .527E+1
 3       30.00           .705E+0
 4       32.75           .355E+0
 5
 6
 7
 8
 9
10
```



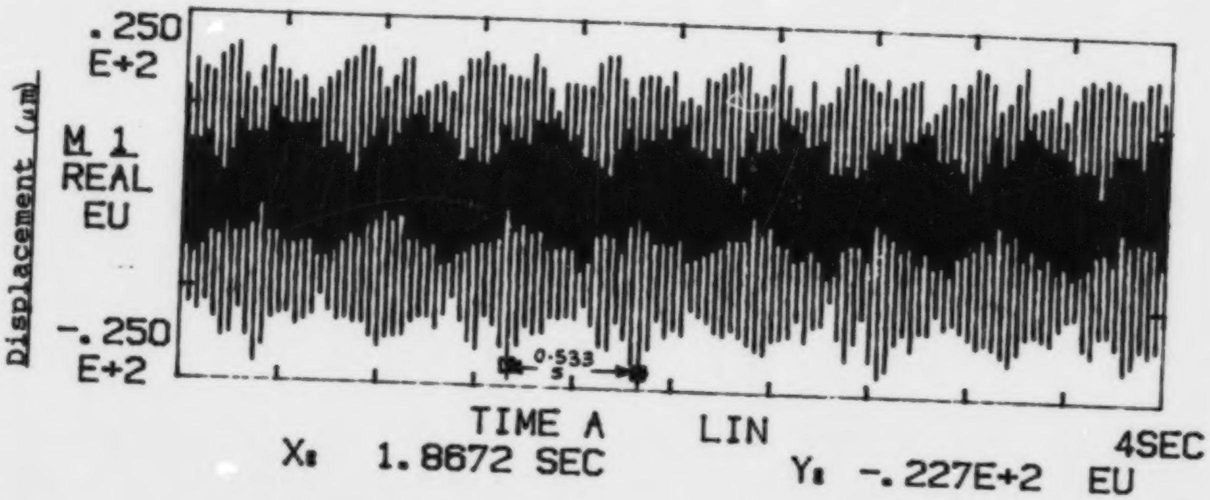
01:34

FIGURE 10

DNGS 'A' EPG#2 AC GENERATOR
INBOARD BEARING - SHAFT DISPLACEMENT SPECTRA (HORIZONTAL DIRECTION)

LOAD = 2.0 MW

```
      TIME   ChA
  1   1.3340 SEC       -.222E+2  EU
  2   1.8672           -.227E+2
  3
  4
  5
  6
  7
  8
  9
 10
```

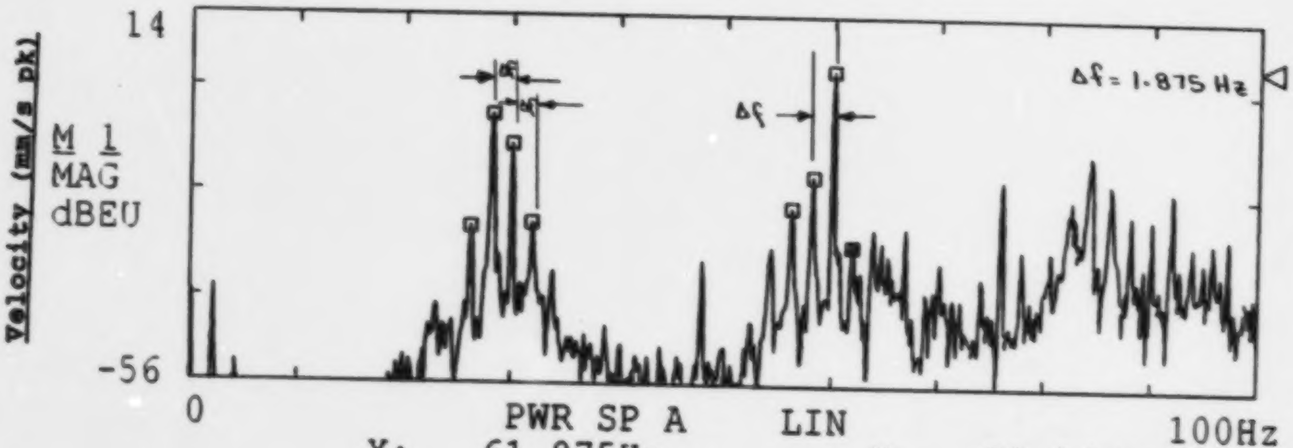


00:11

FIGURE 11

DNGS 'A' EPG#2 AC GENERATOR
INBOARD BEARING CASING VELOCITY SPECTRA (HORIZONTAL DIRECTION)
LOAD = 2.0 MW

	PWR SPECTRUM	ChA		
1	26.125Hz	-26.6dBEU	.467E-1	EU = mm/s
2	28.125	-5.3	.546E+0	
3	30.000	-11.1	.278E+0	
4	31.875	-25.9	.509E-1	
5	56.125	-22.5	.748E-1	
6	58.125	-16.7	.146E+0	
7	60.000	3.5	.150E+1	
8	61.875	-29.8	.325E-1	
9				
10				



X: 61.875Hz Y: -29.8dBEU

01:55

APPENDIX A

DESCRIPTION OF TURBINE-GENERATOR SET

SECTION 1

TURBINE-DRIVEN GENERATOR SET

1.1 GENERAL

The basic turbine-driven generator set (figure 1.1), comprises a Mars two-shaft industrial turbine engine, a speed-reducing gear unit, a generator, a diesel engine-operated hydraulic start system, a package-mounted gage panel, and a floor-standing control console. The console contains most electrical control devices and circuitry necessary for engine and generator operation and protection.

Additional equipment furnished with this generator set, include the batteries and battery chargers for the 24-volt and 120-volt dc systems,the liquid fuel boost assembly, oil cooler assembly and the air intake and exhaust assemblies with associated ducting.

The engine, gearbox, and generator constitute the major elements of the generator set, and are installed on a rigid two-section steel base frame, in an in-line arrangement, with the generator occupying the smaller aft section. Each base frame is a structural steel assembly with beam sections and cross-members welded together, to form a rigid foundation for the engine assembly and driven equipment. Both base sections are provided with heavy mounting flange, and are securely bolted together.

Power from the engine power turbine rotor is transmitted to the reduction gear unit by a tubular output drive shaft. The output drive shaft is enclosed in a two-piece protective oil-tight cover.

The generator input shaft is aligned with the reduction gear unit output shaft, and the two shafts are connected by a limited end float coupling assembly enclosed in a protective safety cover.

An accessory drive assembly for the operation of engine-driven pumps and other accessories that require specific rotational input speeds is included as a separate base-mounted unit. It is located on the engine base section, forward of the engine air inlet, and is connected to the engine compressor nose cone hub by means of a tubular shaft, enclosed in a protective cover.

The generator set is a fully operational package, equipped with all accessories necessary for normal operation when connected to a customer's facilities. It incorporates a full complement of auxiliary systems, including a complete fuel system, an air system with associated devices, a lubricating oil system with related subsystems, a diesel engine-operated hydraulic start system and an electrical control system.

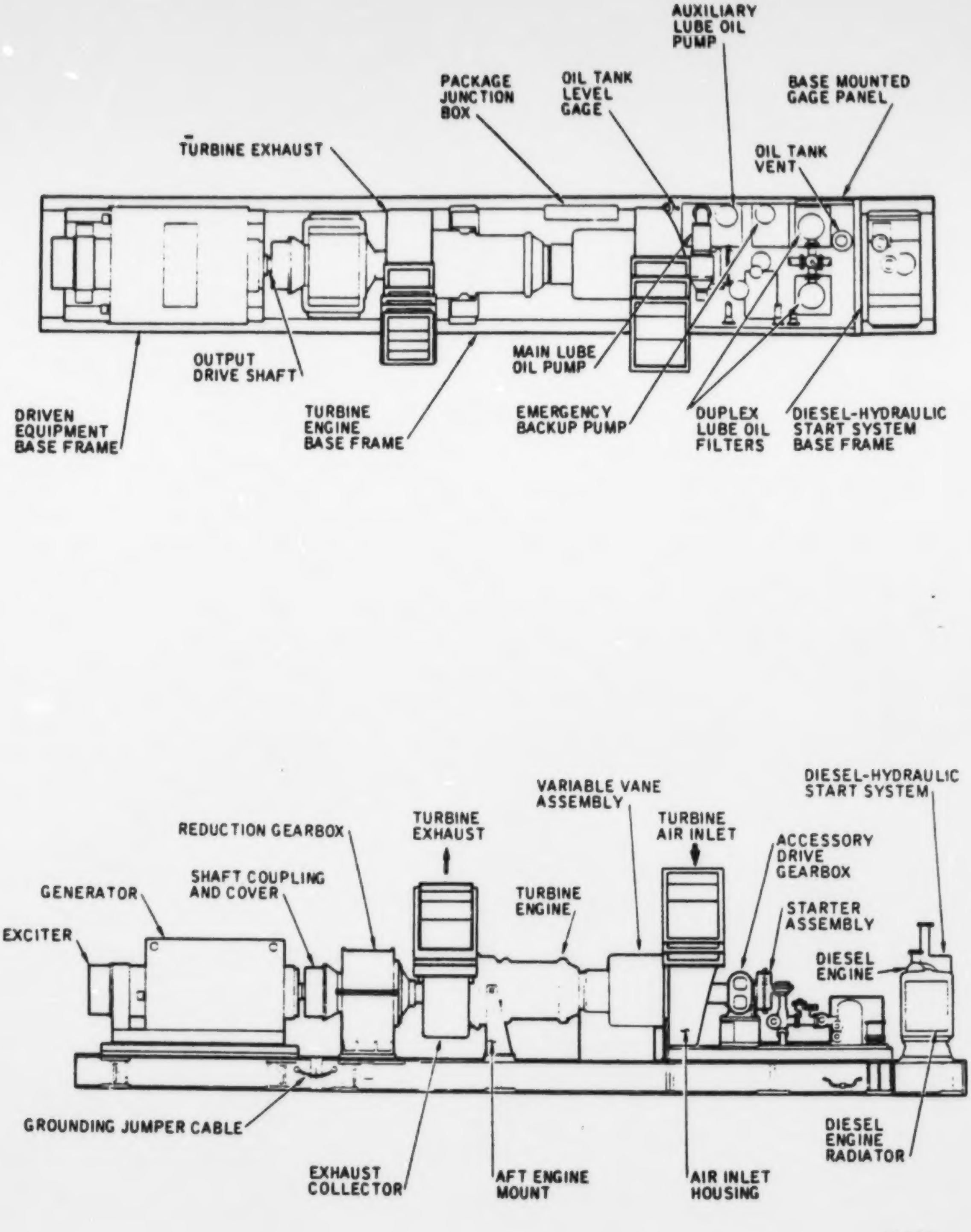

AUXILIARY LUBE OIL PUMP
PACKAGE JUNCTION BOX
OIL TANK LEVEL GAGE
BASE MOUNTED GAGE PANEL
TURBINE EXHAUST
OIL TANK VENT
OUTPUT DRIVE SHAFT
MAIN LUBE OIL PUMP
DRIVEN EQUIPMENT BASE FRAME
TURBINE ENGINE BASE FRAME
EMERGENCY BACKUP PUMP
DUPLEX LUBE OIL FILTERS
DIESEL-HYDRAULIC START SYSTEM BASE FRAME
VARIABLE VANE ASSEMBLY
DIESEL-HYDRAULIC START SYSTEM
REDUCTION GEARBOX
TURBINE EXHAUST
TURBINE AIR INLET
ACCESSORY DRIVE GEARBOX
GENERATOR
SHAFT COUPLING AND COVER
TURBINE ENGINE
STARTER ASSEMBLY
EXCITER
DIESEL ENGINE
GROUNDING JUMPER CABLE
DIESEL ENGINE RADIATOR
EXHAUST COLLECTOR
AFT ENGINE MOUNT
AIR INLET HOUSING
MA100

Figure 1.1. Typical Mars Generator Set Outline

1.2 TURBINE ENGINE

The Mars T-MA-2 turbine engine is of a two-shaft, variable speed, axial-flow design, consisting of a separately mounted accessory drive assembly, air inlet assembly, 15-stage compressor with fixed and variable guide vane assemblies, compressor diffuser assembly, combustor assembly with annular combustion chamber, two-stage gas producer turbine, two-stage power turbine, turbine exhaust diffuser, and exhaust collector. These major components are maintained in accurate alignment by mating flange with pilot surfaces and are bolted together to form a rigid assembly. The power turbine transmits driving power to the driven equipment (i.e., reduction gear unit and generator) through a tubular drive shaft, enclosed in a protective cover. The driven equipment input shaft is carefully aligned with the power turbine output drive shaft, which is firmly supported within the power turbine bearing housing, with the housing attached to the exhaust diffuser in the power turbine section. The engine compressor nose cone hub is also carefully aligned and connected to the input shaft of the separately mounted accessory drive assembly at the forward end of the engine, by means of a short, tubular and enclosed drive shaft.

Note

> Reference locations of components on the engine and entire compressor set are forward, aft, right and left. These directions are established by viewing the set from the driven equipment (aft) end.

1.3 SYSTEMS

The fuel system controls the fuel pressure and automatically regulates the fuel flow according to operating requirements.

The air system pressurizes oil seals in the turbine engine, cools the turbine section components,and bypasses a controlled amount of engine compressor discharge air during starting and low power operation to avoid surge conditions.

The start system comprises a diesel engine, driving a hydraulic pump which provide the necessary hydraulic power to operate a Pelton wheel-type turbine starter, together with associated control devices that enable the engine to crank and accelerate smoothly to 65 percent engine speed at which time the start system shuts down, the starter clutch overruns, and the engine accelerates under its own power to operating (no load) speed.

The lubricating oil system circulates oil under pressure to the various working parts of the turbine engine and driven equipment. In addition, the system supplies oil at engine inlet pressure to related hydraulic subsystems. The system is supplied from an oil tank, located in the base frame. Proper oil temperatures are maintained by an oil cooler and thermostatic valves, and by oil tank heaters. The oil cooler is remotely installed, and a number of optional installation plans are available, depending on station requirements.

The servo oil system provides oil pressure to operate actuating and control devices in the variable inlet guide vane, bleed air valve, and fuel control actuator subsystems.

The electrical control system, operating on 24-volt dc power, provides for automatic starting, acceleration to operating speed, engine and driven equipment monitoring during operating, and normal and emergency (malfunction) shutdown. During operation, the electrical control system, by means of automatic warning and shutdown devices, protects the turbine engine and driven equipment from possible damage resulting from hazards such as overspeed, high engine temperatures, low lubricating oil pressure, low oil level, excessive oil temperature, and generator malfunction. Other malfunction shutdown devices are provided, and special devices may be added according to application requirements.

The electrical control system is operated from a remotely installed control console, incorporating a turbine engine control panel and a generator metering panel with all necessary switches, pushbuttons, meters and indicators for engine and generator operational status. The free-standing control console may be installed in a separate control room, in accordance with installation requirements. Remote operation of the generator set is also possible upon completion of minor changes in the dc control system wiring in accordance with the electrical system schematic.

1.4 REDUCTION GEAR UNIT

The reduction gear unit used with the Mars generator set has an epicyclic star gear design. Assembly and disassembly is simplified by a split housing, the upper half of which can be removed easily for inspection and maintenance. The gears can be completely serviced without moving the lower case housing.

The gear unit is designed for a maximum input of 10 440 kW (14 000 hp) at an output speed of 1800 rpm for 60 Hz generator operation.

The gear unit is mounted on the engine base and coupled to the engine through a balanced high speed shaft, splined at both ends. The shaft is a matched part of the gear unit. The output shaft is coupled to the generator through a gear coupling with limited end float. Gear lubrication is from the main turbine oil system, and output shaft seal air is supplied by the turbine.

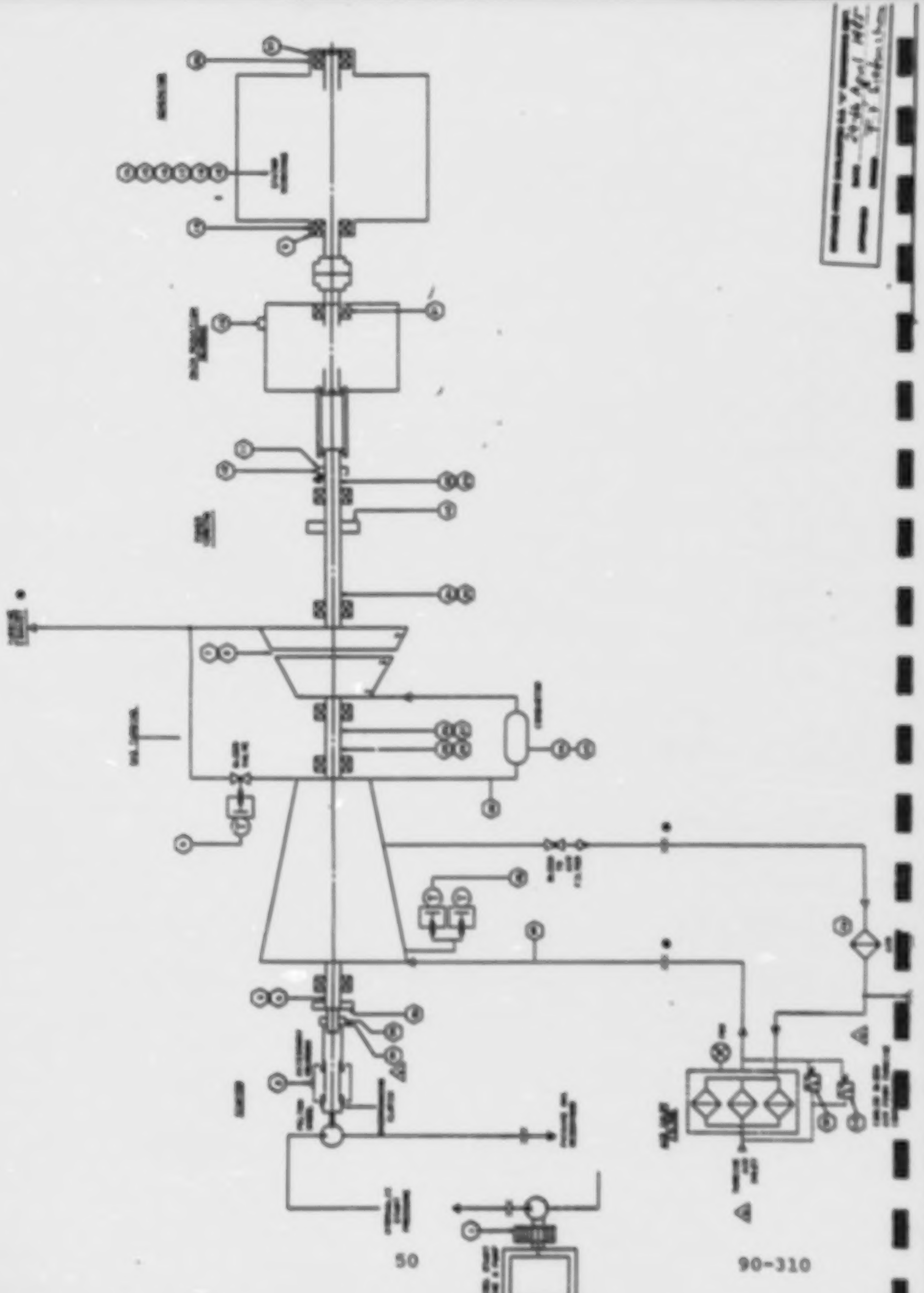
1.5 GENERATOR

The generator is mounted on a steel base separate from the base containing the turbine engine and the reduction gear unit. The generator base, aligned and matchmarked to the engine base at the factory, is bolted to the engine base. The generator is positioned in alignment with the reduction gear unit by means of shims and adjustment screws, and bolted in place.

The generator is a two-bearing (sleeve-type), self-ventilated, air-cooled, three-phase, 4160 Vac, 60 Hz, 1800 rpm, ac generator of drip-proof construction, equipped with a brushless type exciter using a rotating rectifier bridge circuit. The rectifier is mounted on the rotor shaft and supplies the field excitation current for the generator.

1.6 ENVIRONMENT

The standard turbine generator set is designed for operation (when installed in a weather-proof enclosure) at seal level and up to 2438 meters (8000 feet) elevation, at engine air inlet (ambient) temperatures ranging from -29°C (-20°F) to +43°C (-110°F). Special accessories are necessary for operation at higher elevations or in extreme temperature, salt or dust conditions. The type of lubricating oil used may cause restrictions on operation in extreme temperatures. In particular, the lubricating oil contained in the oil tank, oil lines, engine and oil cooler should have suitable minimum and maximum viscosities for the ambient starting temperature.



28 27 26 25 24

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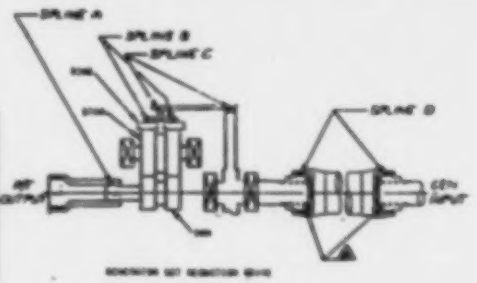
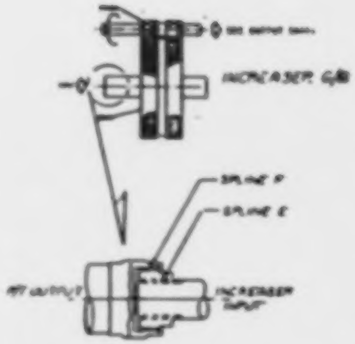
51

90-310


SPLINE A
SPLINE B
SPLINE C
SPLINE D
ART OUTPUT
GEN INPUT
GENERATOR SET REDUCTION DRIVE

GENERATOR SET REDUCTION DRIVE

PART NUMBER		GEARING ELEMENT SPEED	NO. OF TEETH	RTE	GEAR MESH FREQ (HZ)		SPLINE MESH FREQ (HZ) A	B	C	D
125538-100 [illegible]	SUN STAR RING	142.8 77.6 30.0	25 46 119	2.1 0.7	3,570	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]-300 [illegible]	SUN STAR RING	133.3 78.3 30.0	27 46 120	2.9 1.3	3,600	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]-100 [illegible]	SUN STAR RING	134.3 70.2 34.0	22 57 103	3.0 0.8	3,030	[illegible]	[illegible]	[illegible]	[illegible]	
[illegible]-300 [illegible]	SUN STAR RING	142.0 76.0 30.0	25 47 118	3.0 0.6	3,570	4.76	[illegible]	[illegible]	[illegible]	
[illegible]-100 [illegible]	SUN STAR RING	142.6 61.5 25.0	24 [illegible] 138	10.3 0.9	3,400	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
[illegible]-300 126340-100 [illegible]	SUN STAR RING	135.0 62.5 25.0	22 48 119	8.6 0.3	2,970	5.4	[illegible]	[illegible]	[illegible]	
[illegible]-400 [illegible]	SUN STAR RING	136.3 61.9 25.0	20 44 109	12.4 0.6	2,725	5.45	NOT DETERMINED			
[illegible]-300 [illegible]	SUN STAR RING	142.5 46.8 20.0	24 73 171	2.0 0.3	3,400	7.13	[illegible]	[illegible]	[illegible]	[illegible]


INCREASER G/B
SPLINE F
SPLINE E
ART OUTPUT
INCREASER INPUT

CS/MD INCREASER DRIVE

SOLAR PART NO	GEARING GEAR RATIO	OUTPUT SPEED (HZ) PINION	GEAR	NUMBER OF TEETH PINION	GEAR	RTE	GEAR MESH FREQ (HZ)	INPUT SPLINE MESH FREQ (HZ) SPLINE E	SPLINE F
122162-1	.547	262.5	143.3	41	75	3.5	10,760	6,030	6,880
-2	.616	232.5		45	73	3.2	10,464		
-3	.716	200.1		48	67	3.0	9,603		
-4	.815	175.8		53	65	2.7	9,317		
-5	.495	290.0		45	91	3.8	13,043		
-6	.446	321.6		41	92	3.3	13,187		
-7	.424	354.7		40	95	3.6	14,150		
-8	.366	391.3		37	101	3.8	14,477		
122162-9	.547	262.5	143.3	41	75	3.5	10,730	6,030	6,880

OUTPUT SHAFT ASSY SPLINE MESH FREQ (HZ)

SOLAR PART NO	SPLINE G (T-TEETH)	SPLINE H (32 TEETH)	SPLINE J (T-TEETH)	SPLINE K (T-TEETH)	CPPBA MODEL INDEX NUMBER
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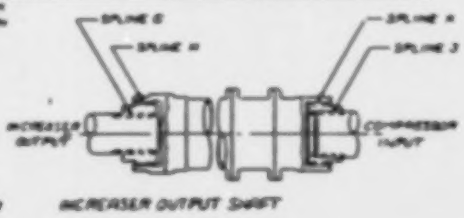
[illegible]	[illegible]	12,078	[illegible]	[illegible]	[illegible]
[illegible]			[illegible]	[illegible]	[illegible]


SPLINE G
SPLINE H
SPLINE K
SPLINE J
INCREASER OUTPUT
COMPRESSOR INPUT
INCREASER OUTPUT SHAFT

MABS GP 8300 lbs
MABS PT 1130 lbs

EPG 2 RGB

52

NOTES

1. FREQUENCIES ARE CALCULATED USING NOMINAL SUN GEAR SPEEDS FOR EPICYCLIC REDUCTION DRIVES & NOMINAL GEAR SPEEDS FOR INCREASER DRIVES. FOR OTHER SPEEDS USE PROPORTIONAL RATIO
2. SIDEBAND FREQ = GEAR MESH FREQ ± N TIMES PINION OR GEAR SPEED
3. RTE - RATED TRANSMISSION ERROR = MODULATING CYCLES PER SEC WHEN CORRESPONDING TEETH OF COMPANION GEARS MAKE CONTACT
- MADE BY PHILADELPHIA GEAR, KING OF PRUSSIA, PA
- MADE BY ALLEN GEAR, [illegible]
- FREQUENCIES CALCULATED USING 122162-1 G/B, FOR OTHER G/B, USE PROPORTIONAL RATIO
- FREQUENCIES CALCULATED USING 122162-[illegible] G/B, FOR OTHER G/B, USE PROPORTIONAL RATIO.
4. FOR EPICYCLIC GEAR BOXES, EXPECT TO SEE GEAR MESH FREQUENCIES [illegible] TIMES FUNDAMENTAL FREQUENCY
- FREQUENCY EITHER AT ROTATIONAL SPEED OR 2X, DEPENDING ON NUMBER OF KEYS (1 OR 2)
- INPUT RPM/OUTPUT RPM
- [illegible] COUPLING ASSY ([illegible]), 34 TEETH

- [illegible] COUPLING ASSY ([illegible]), 62 TEETH
- [illegible] COUPLING ASSY ([illegible]), 70 TEETH

VIBRATION FREQUENCY DATA
CHART - OUTPUT G.B., VENDOR

SIZE	CODE IDENT NO	DRAWING NO
D	50820	134620

3

90-010

APPENDIX B

AC GENERATOR VELOCITY AND DISPLACEMENT SPECTRA

TABLE B1

DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2 - AC GENERATOR FIGURE NUMBERS OF VELOCITY AND DISPLACEMENT SPECTRA

Measurement		FFT Spectrum Figure No. Load (MW) 0	1	1.5	2	3	4	5	6.8
Outboard Bearing Casing Velocity	Vertical Direction	B1	B2	B3	B4	B5	B6	B7	B8
	Horizontal Direction	B9	B10	B11	B12	B13	B14	B15	B16
Inboard Bearing Casing Velocity	Vertical Direction	B17	B18	B19	B20	B21	B22	B23	B24
	Horizontal Direction	B25	B26	B27	B28	B29	B30	B31	B32
	Axial Direction	B32	B34	B35	B36	B37	B38	B39	B40
Outboard Bearing Shaft Displacement	Vertical Direction	B41	B42	B43	B44	B45	B46	B47	B48
	Horizontal Direction	B49	B50	B51	B52	B53	B54	B55	B56
Inboard Bearing Shaft Displacement	Vertical Direction	B57	B58	B59	B60	B61	B62	B63	B64
	Horizontal Direction	B65	B66	B67	B68	B69	B70	B71	B72

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. VERT.
PROCESS CONDITION :- LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	0.19
2	60.1	0.14
3	143.1	0.14
4	120.3	0.10
5	147.9	0.06
6	90.2	0.04
7	126.3	0.03
8	33.7	0.03
9	105.8	0.02
10	116.7	0.02

SCALE: Linear

DATE: 19-FEB-88

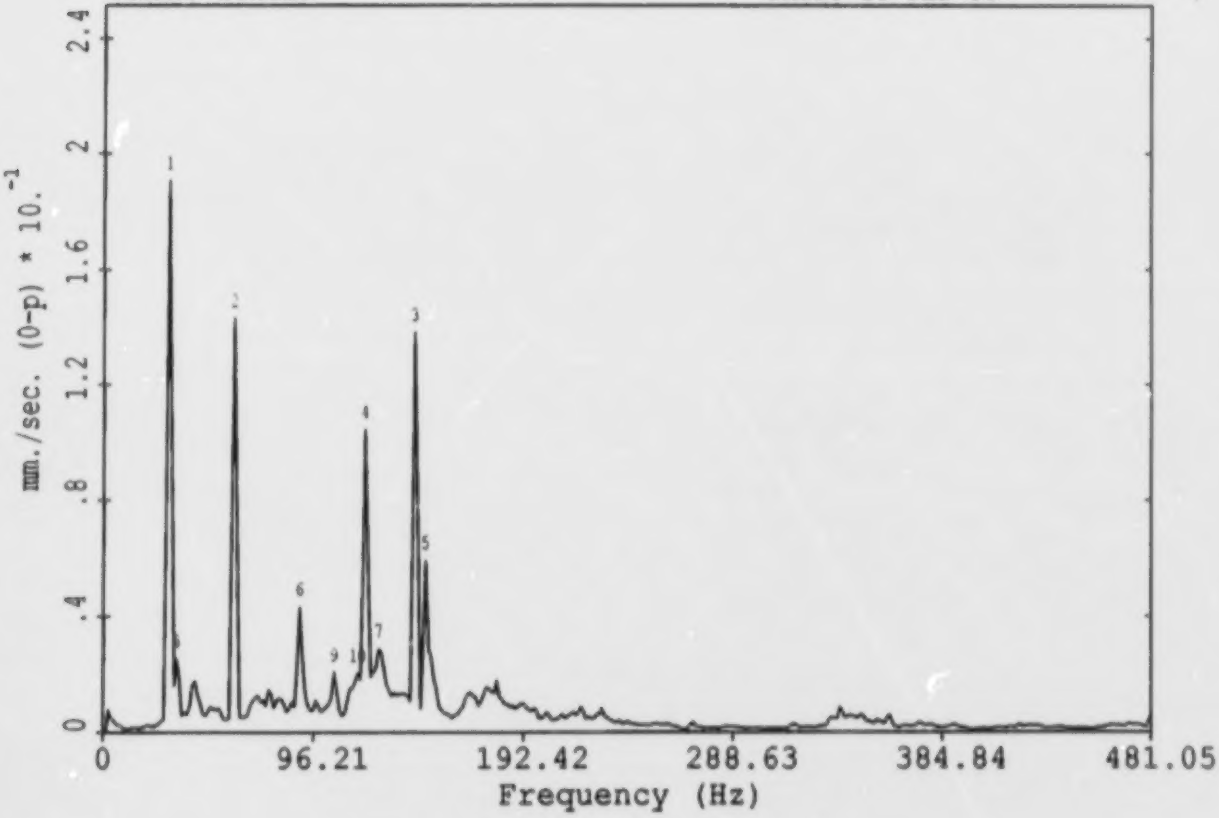


FIGURE B1

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. VERT.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.26
2	30.1	0.22
3	143.1	0.12
4	81.8	0.08
5	120.3	0.07
6	75.8	0.06
7	109.4	0.05
8	129.9	0.05
9	152.7	0.05
10	114.3	0.05

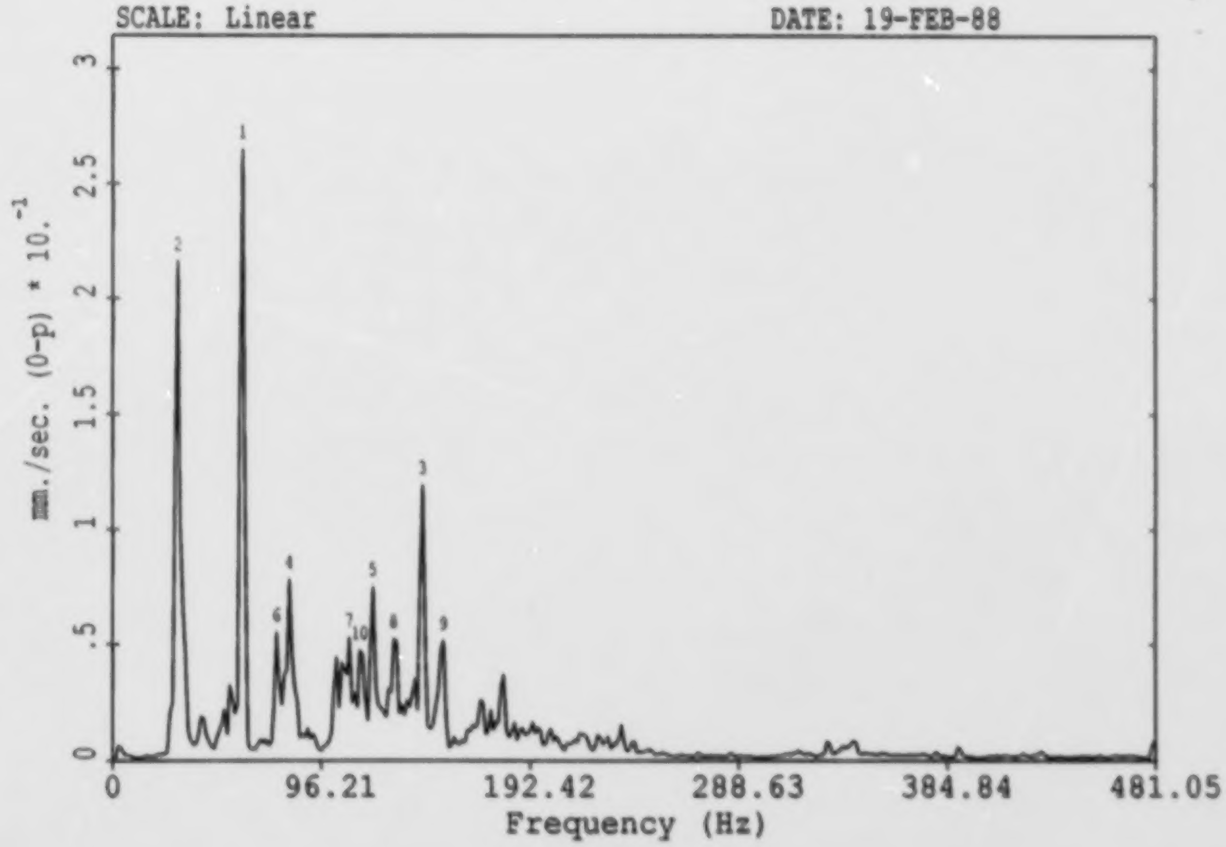


FIGURE B2

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.51
2	30.1	0.22
3	143.1	0.18
4	120.3	0.13
5	150.3	0.08
6	75.8	0.05
7	210.5	0.04
8	180.4	0.04
9	55.3	0.04
10	138.3	0.04

SCALE: Linear DATE: 19-FEB-88

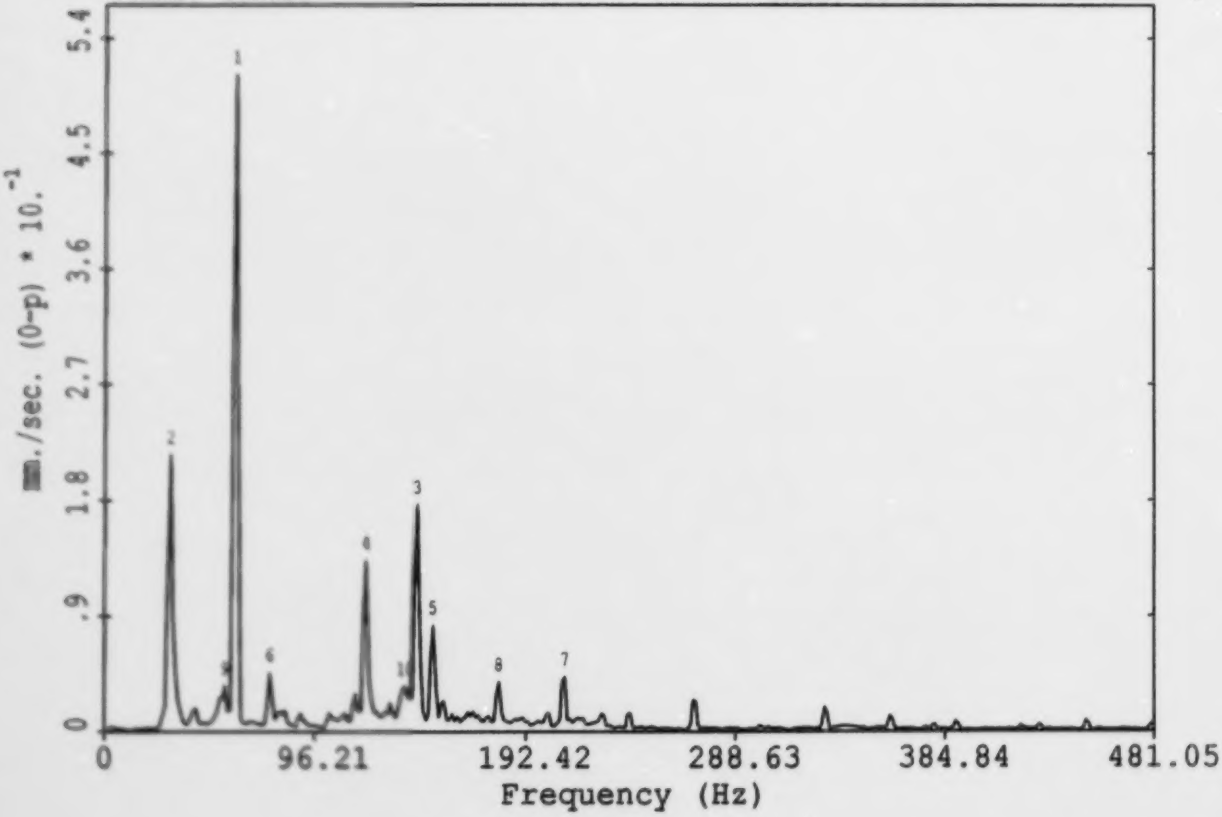


FIGURE B3

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. VERT.
PROCESS CONDITION :- LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.53
2	30.1	0.22
3	143.1	0.20
4	120.3	0.12
5	150.3	0.10
6	75.8	0.05
7	116.7	0.05
8	270.6	0.04
9	210.5	0.04
10	155.1	0.04

SCALE: Linear

DATE: 19-FEB-88

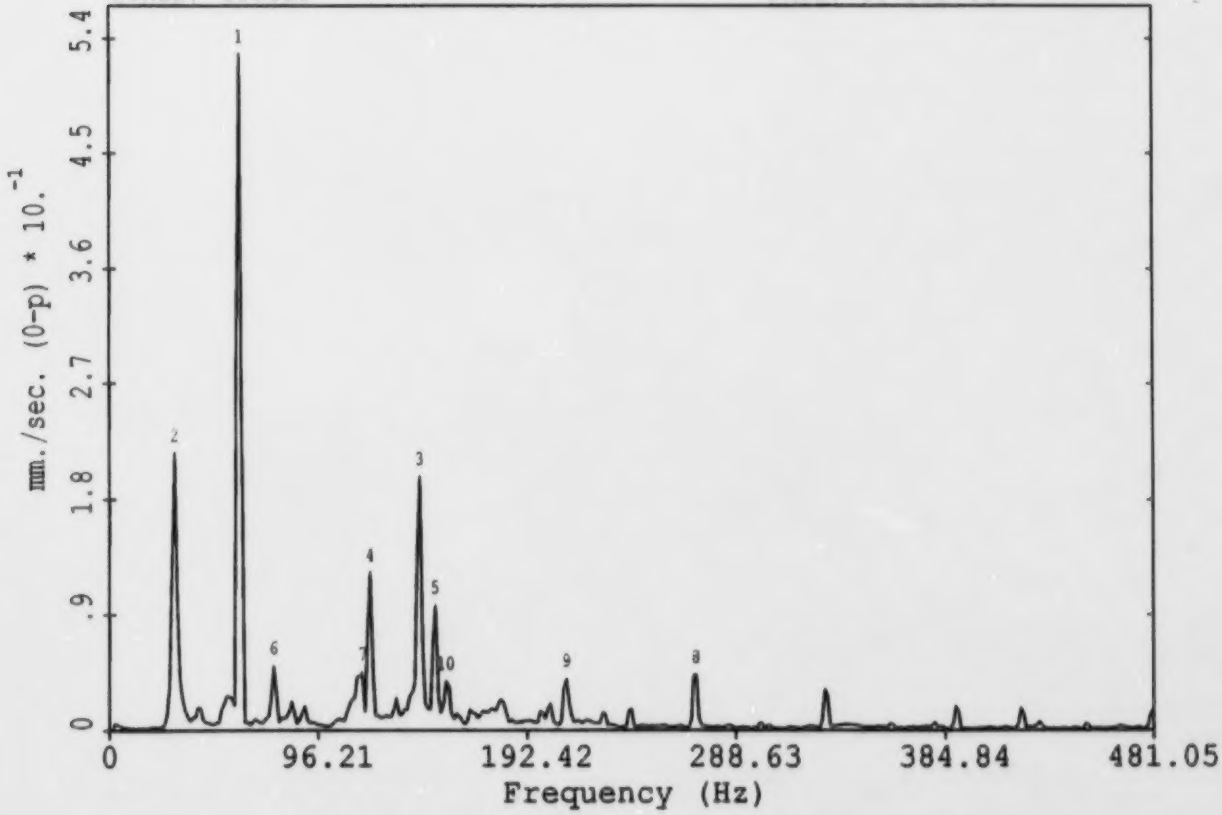


FIGURE B4

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. VERT.
PROCESS CONDITION :- LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.47
2	143.1	0.20
3	30.1	0.16
4	180.4	0.14
5	120.3	0.09
6	75.8	0.07
7	150.3	0.06
8	270.6	0.05
9	210.5	0.05
10	329.5	0.04

SCALE: Linear DATE: 19-FEB-88

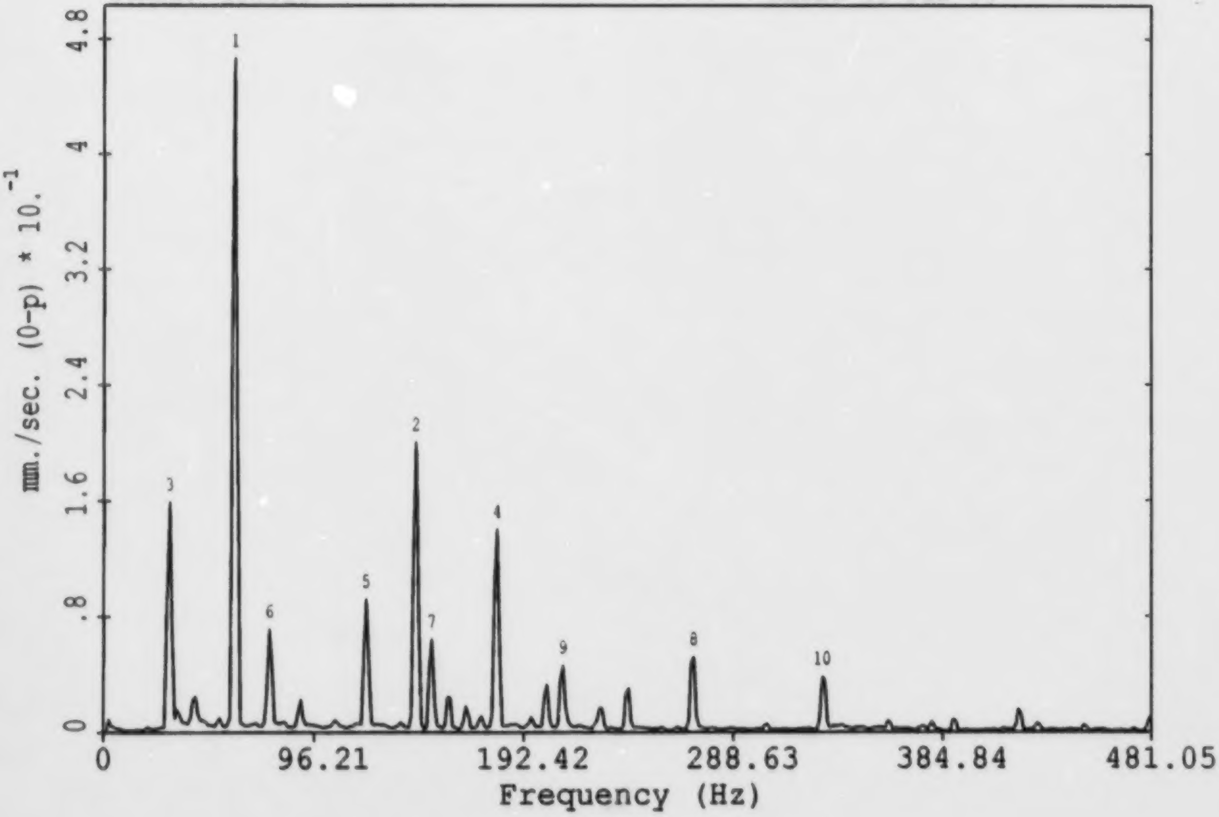


FIGURE B5

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. VERT.
PROCESS CONDITION :- LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.32
2	30.1	0.18
3	75.8	0.11
4	143.1	0.10
5	180.4	0.06
6	120.3	0.06
7	150.3	0.06
8	161.2	0.06
9	269.4	0.05
10	329.5	0.04

SCALE: Linear DATE: 19-FEB-88

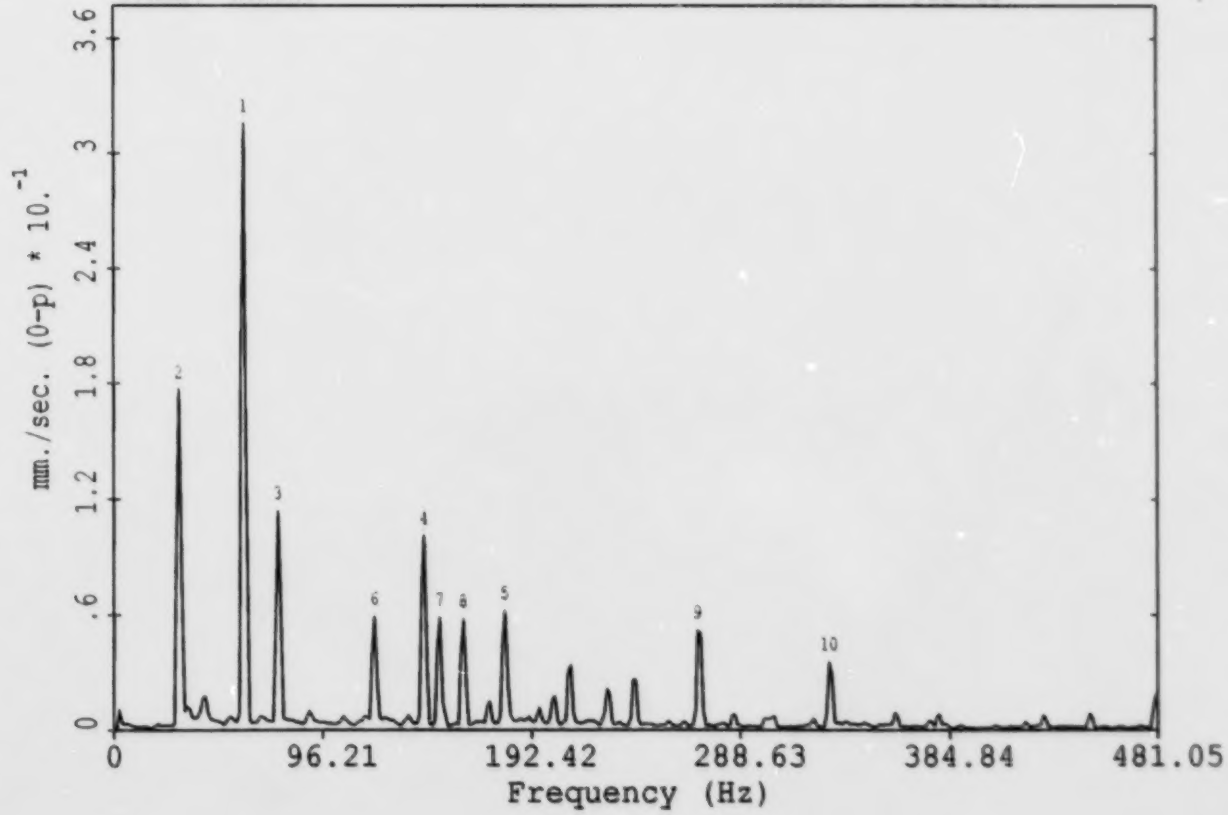


FIGURE B6

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. VERT.
PROCESS CONDITION :- LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.23
2	30.1	0.15
3	75.8	0.13
4	180.4	0.10
5	143.1	0.08
6	120.3	0.06
7	150.3	0.06
8	269.4	0.05
9	329.5	0.04
10	42.1	0.03

SCALE: Linear

DATE: 19-FEB-88

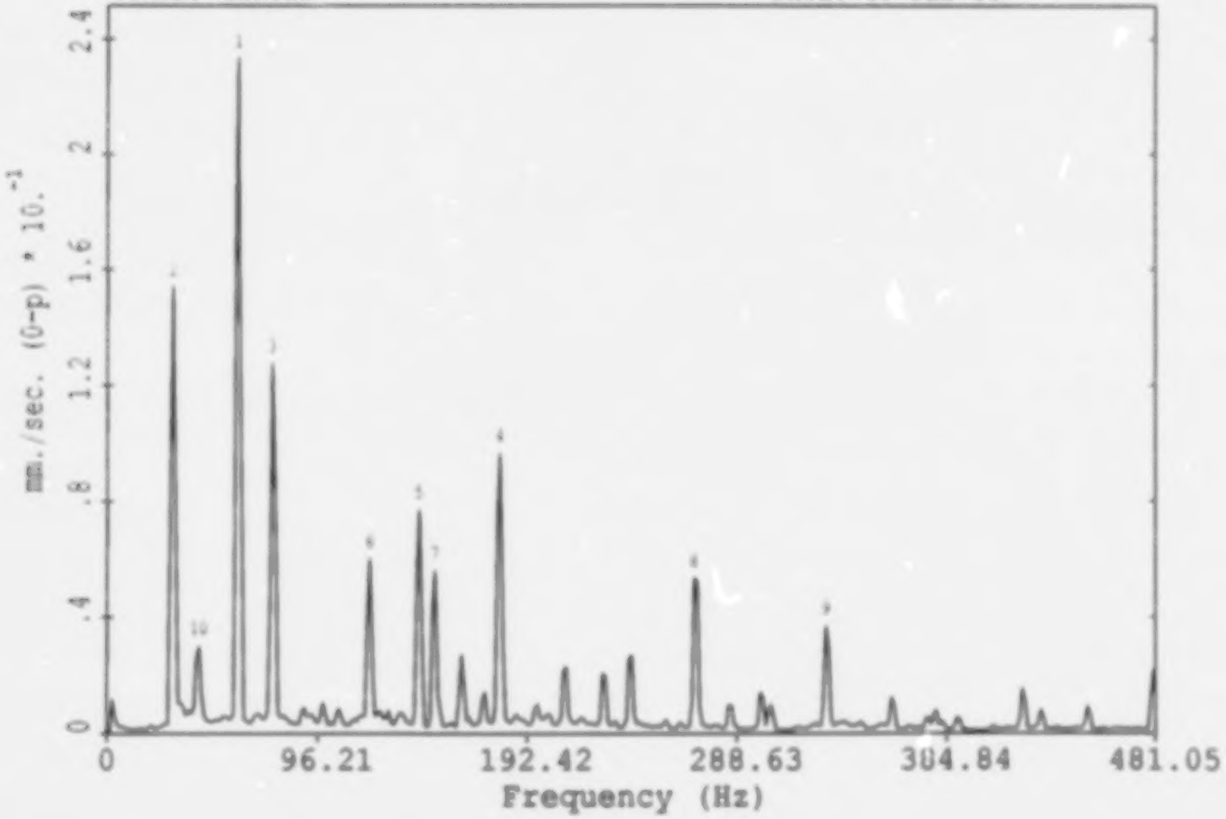


FIGURE B7

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. VERT.
PROCESS CONDITION ;- LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.23
2	75.8	0.15
3	30.1	0.14
4	180.4	0.13
5	167.2	0.06
6	143.1	0.05
7	150.3	0.05
8	123.9	0.03
9	419.7	0.03
10	120.3	0.03

SCALE: Linear DATE: 19-FEB-88

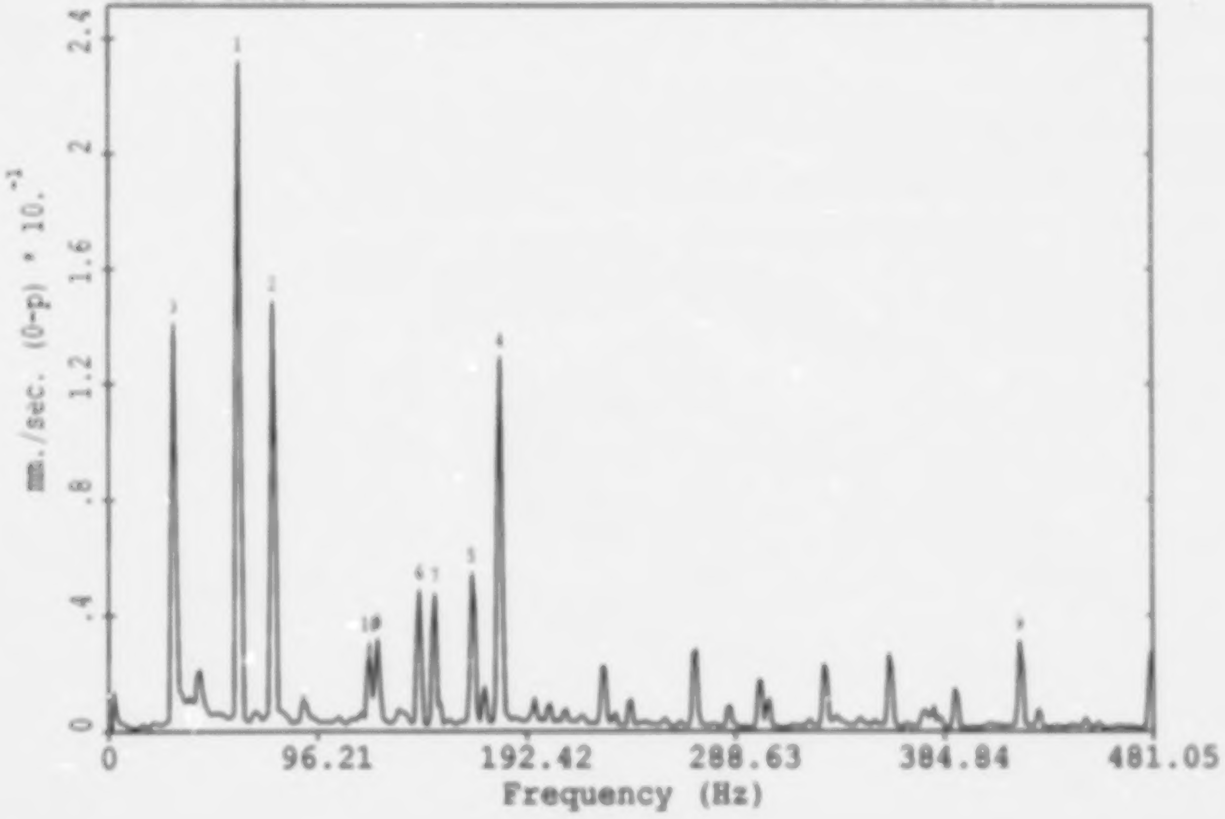


FIGURE B8

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. HOR.
PROCESS CONDITION :- LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
2	60.1	0.26
3	30.1	0.14
4	64.9	0.09
5	120.3	0.07
6	143.1	0.07
7	72.2	0.06
8	180.4	0.04
9	147.9	0.04
10	150.3	0.03

SCALE: Linear

DATE: 19-FEB-88

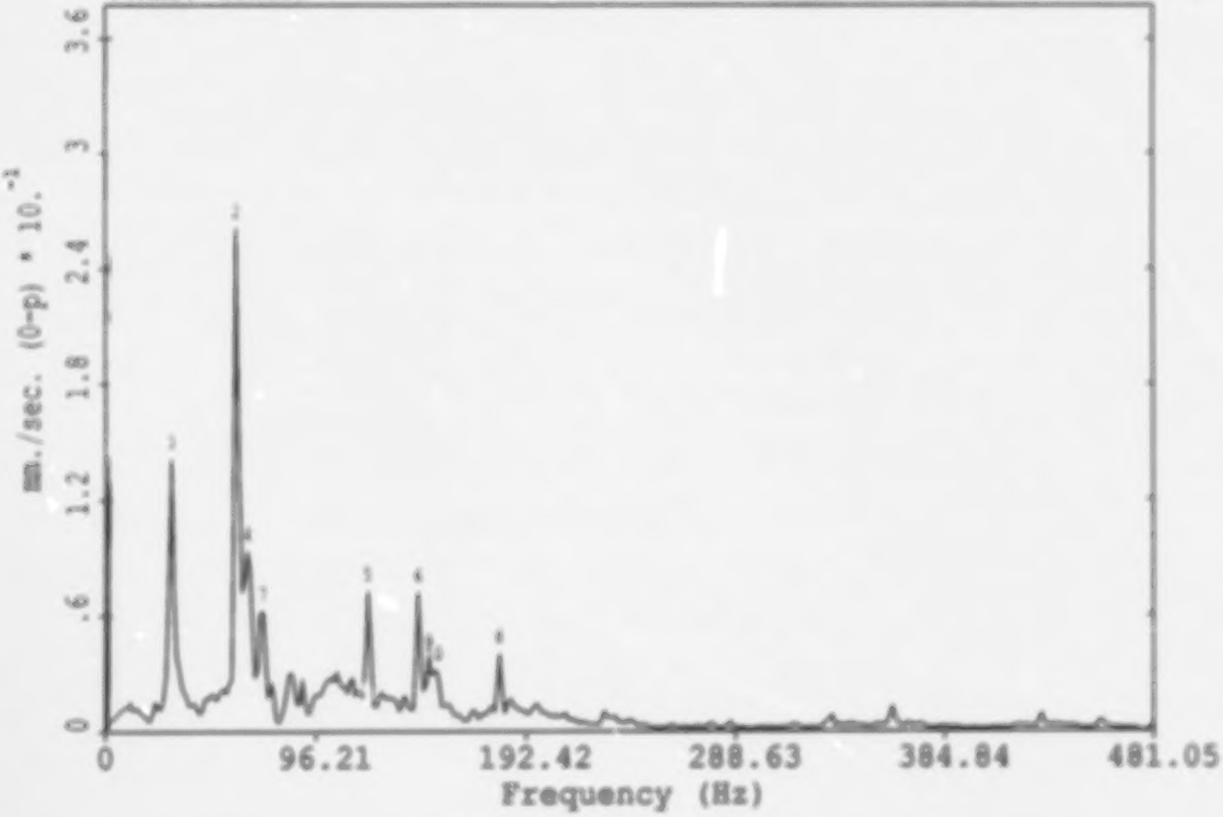


FIGURE B9

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. HOR.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	27.7	0.45
2	30.1	0.31
3	60.1	0.20
4	143.1	0.13
5	2.4	0.12
6	120.3	0.12
7	84.2	0.11
8	109.4	0.09
9	81.8	0.07
10	105.8	0.06

SCALE: Linear DATE: 19-FEB-88

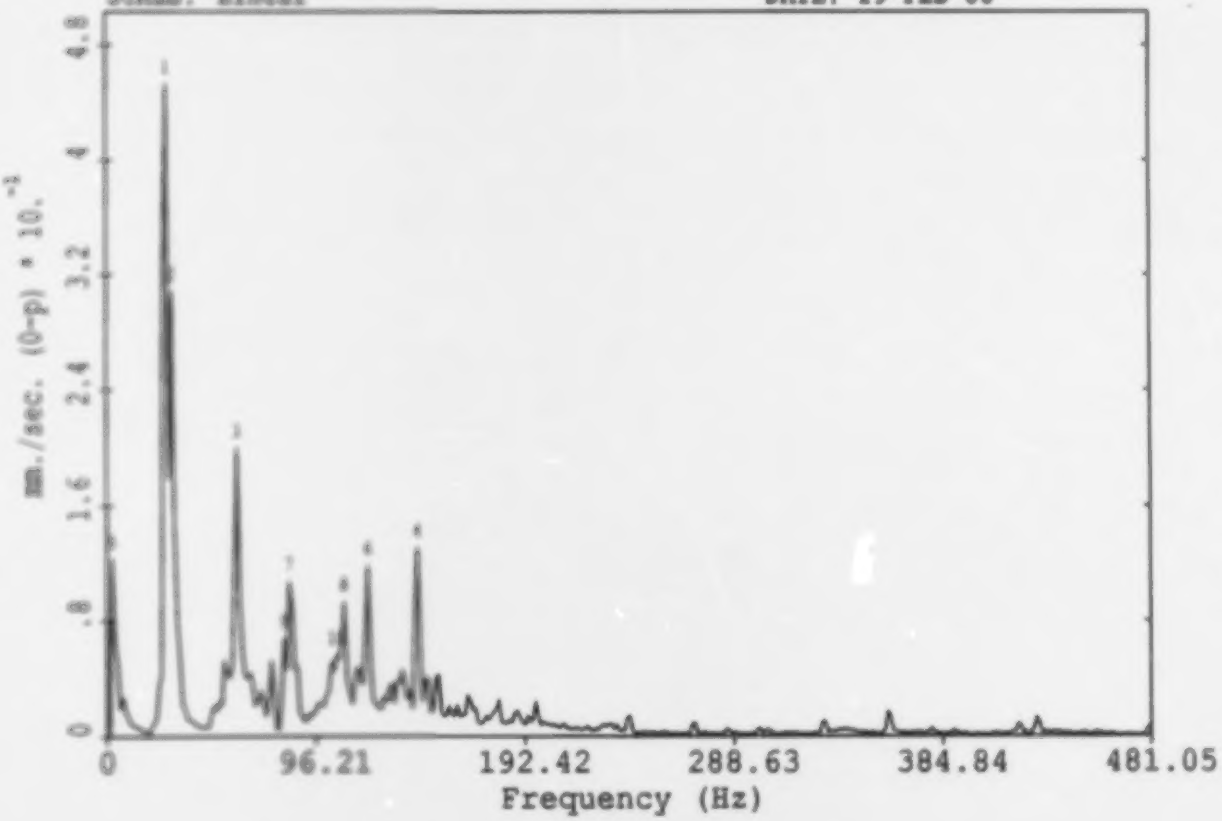


FIGURE B10

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. HOR.
PROCESS CONDITION :- LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.51
2	27.7	0.45
3	143.1	0.28
4	120.3	0.26
5	150.3	0.12
6	55.3	0.11
7	85.4	0.08
8	180.4	0.07
9	83.0	0.07
10	115.5	0.06

SCALE: Linear DATE: 19-FEB-88

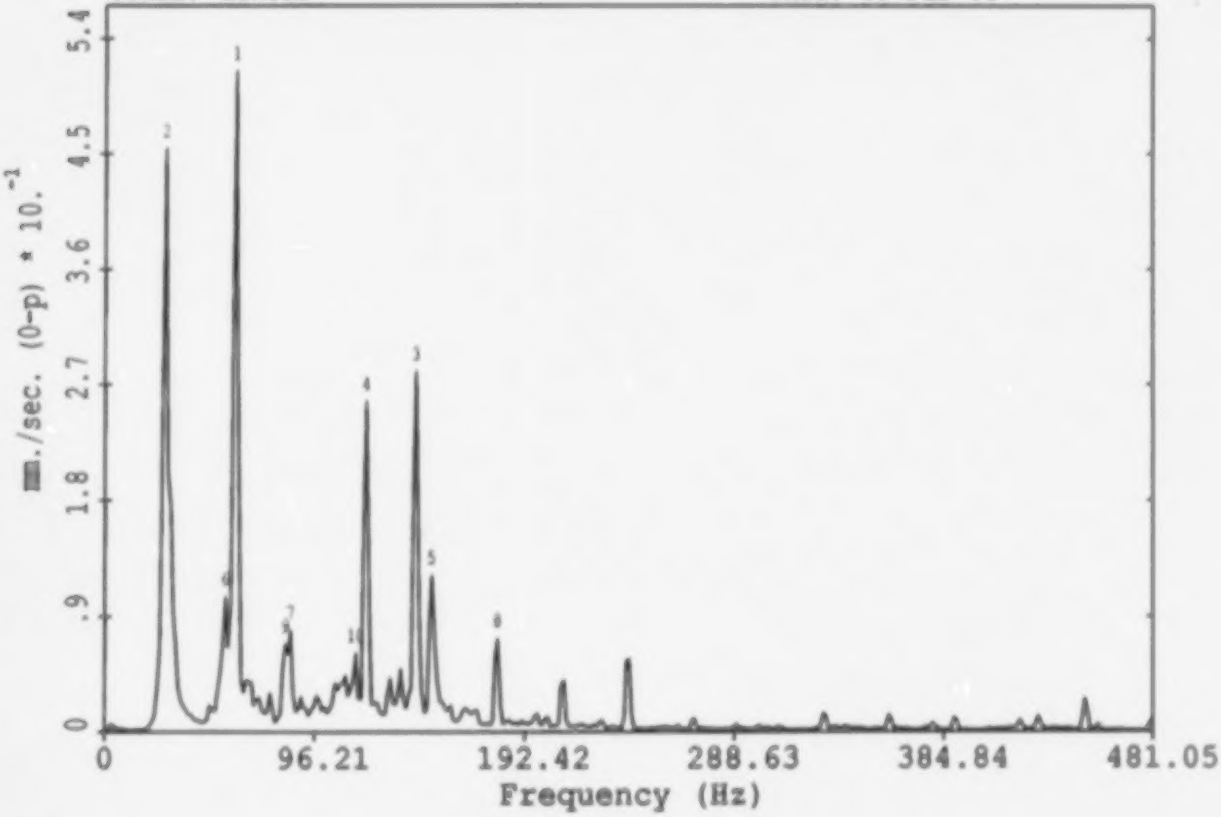


FIGURE B11

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. HOR.
PROCESS CONDITION :- LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.68
2	27.7	0.60
3	120.3	0.41
4	143.1	0.37
5	84.2	0.16
6	150.3	0.13
7	180.4	0.09
8	155.1	0.07
9	111.8	0.07
10	240.5	0.06

SCALE: Linear

DATE: 19-FEB-88

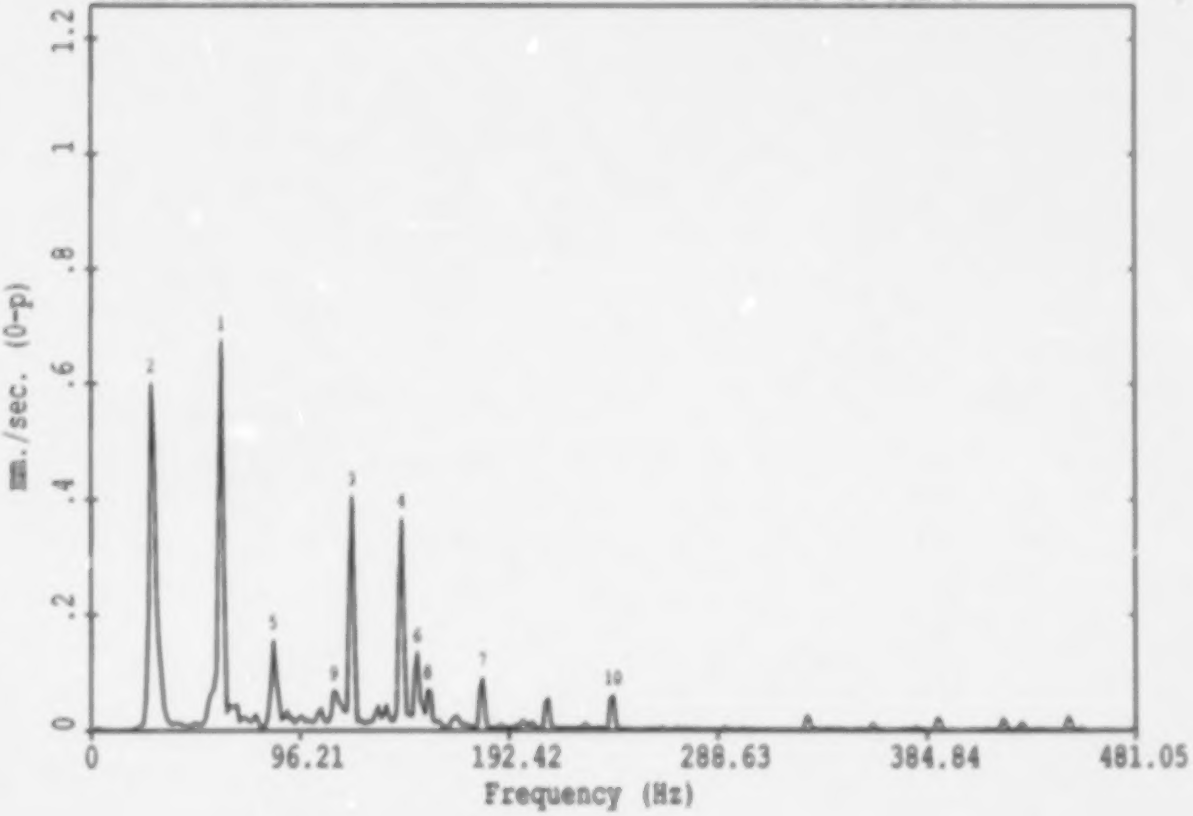


FIGURE B12

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. HOR.
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.90
2	143.1	0.49
3	120.3	0.34
4	150.3	0.14
5	30.1	0.12
6	157.5	0.09
7	180.4	0.07
8	210.5	0.07
9	105.8	0.06
10	240.5	0.05

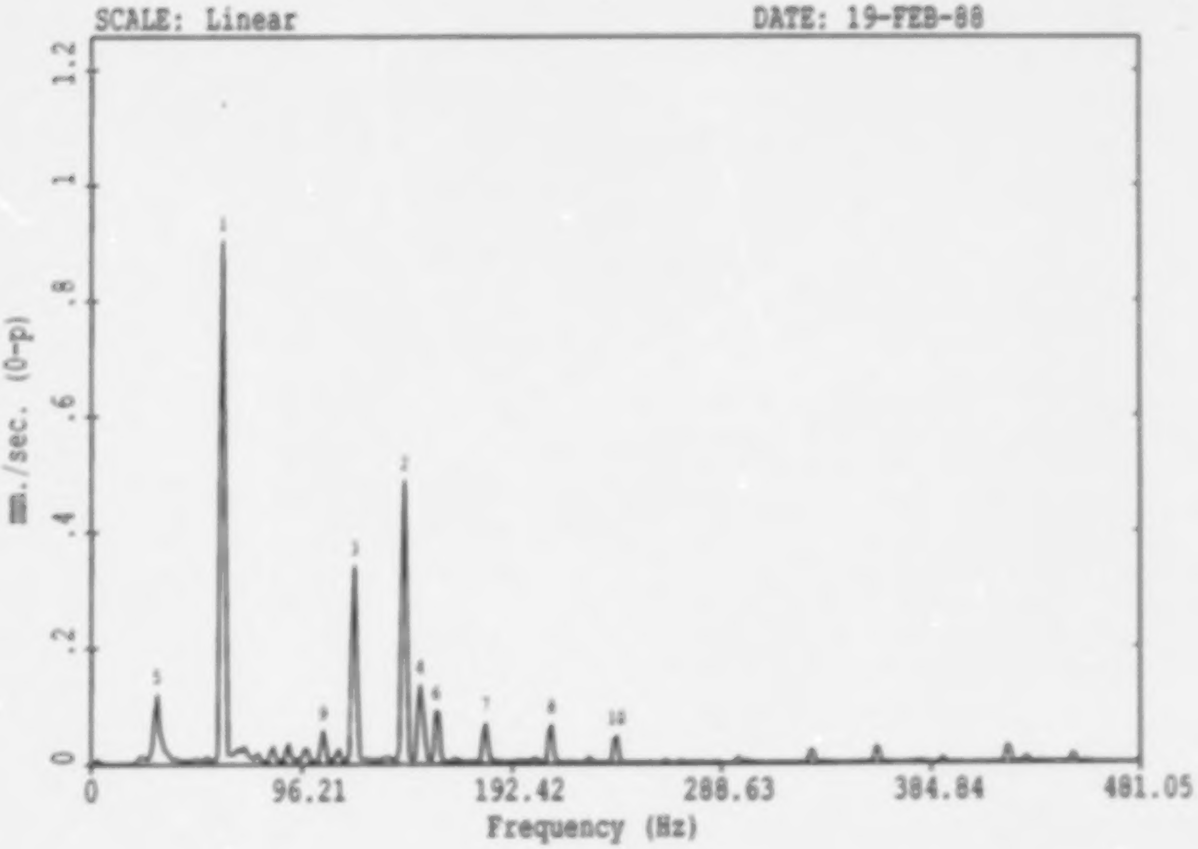


FIGURE B13

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. HOR.
PROCESS CONDITION :- LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.54
2	120.3	0.42
3	30.1	0.24
4	161.2	0.18
5	150.3	0.15
6	60.1	0.08
7	210.5	0.07
8	135.9	0.05
9	359.6	0.04
10	240.5	0.04

SCALE: Linear

DATE: 19-FEB-88

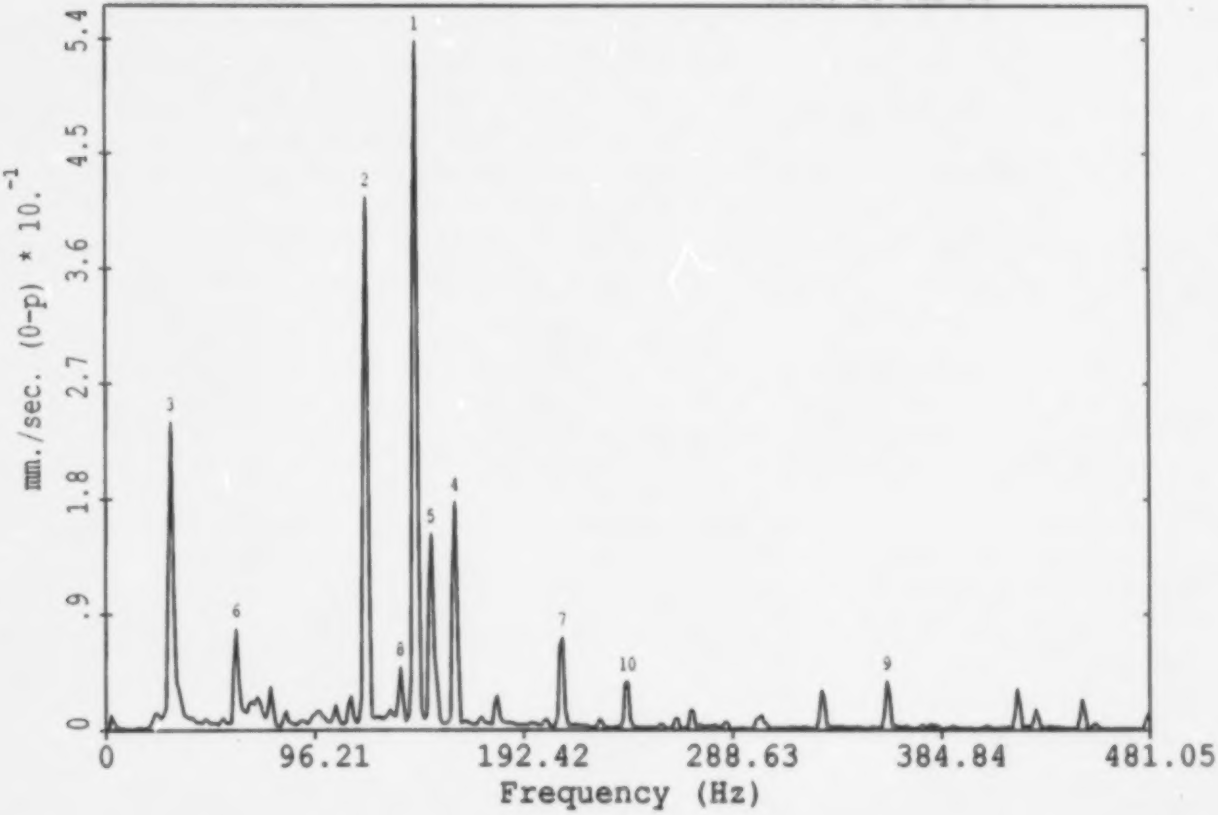


FIGURE B14

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.54
2	30.1	0.47
3	120.3	0.37
4	60.1	0.21
5	150.3	0.12
6	162.4	0.10
7	210.5	0.09
8	135.9	0.06
9	359.6	0.05
10	329.5	0.04

SCALE: Linear DATE: 19-FEB-88

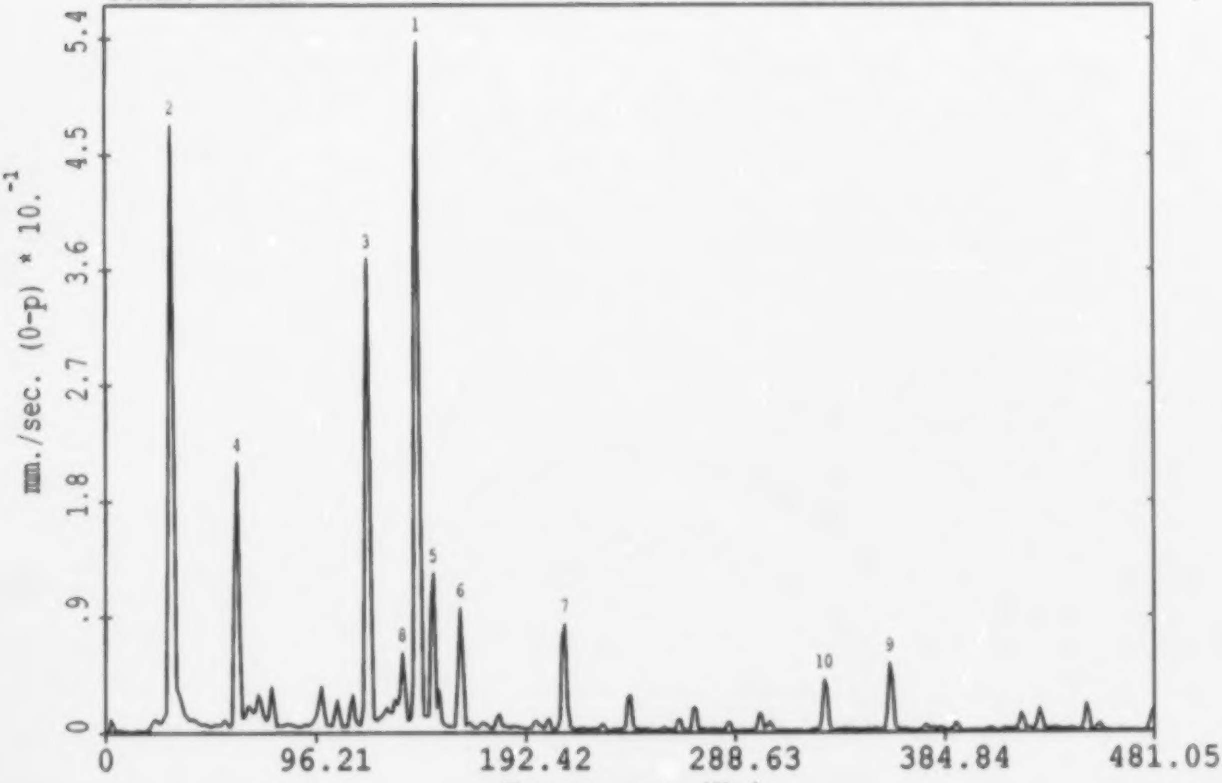


FIGURE B15

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR OB BRG CASING VEL. HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	0.83
2	143.1	0.54
3	120.3	0.35
4	60.1	0.22
5	150.3	0.15
6	167.2	0.12
7	210.5	0.07
8	135.9	0.07
9	359.6	0.05
10	329.5	0.04

SCALE: Linear

DATE: 19-FEB-88

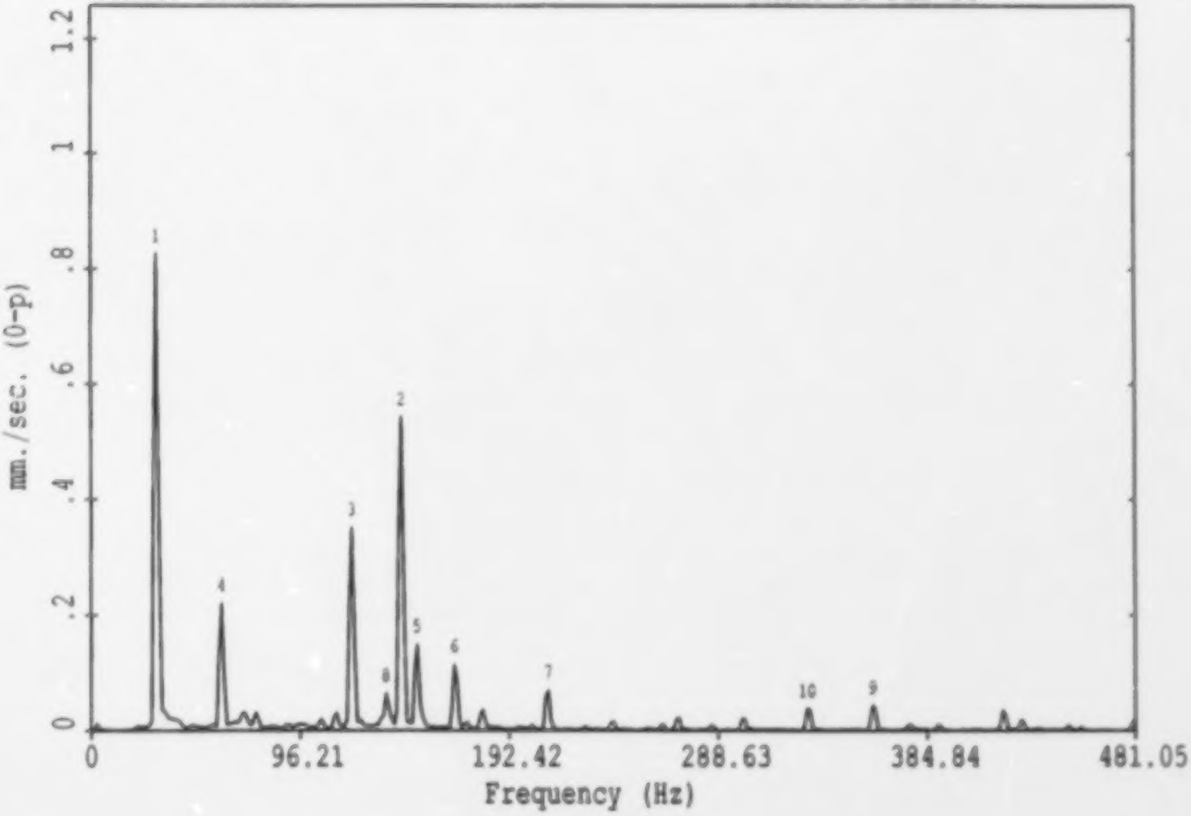


FIGURE B16

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. VERT
PROCESS CONDITION :- LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.37
2	30.1	0.22
3	143.1	0.14
4	147.9	0.07
5	116.7	0.05
6	126.3	0.05
7	150.3	0.05
8	105.8	0.04
9	113.0	0.04
10	121.5	0.04

SCALE: Linear DATE: 19-FEB-88

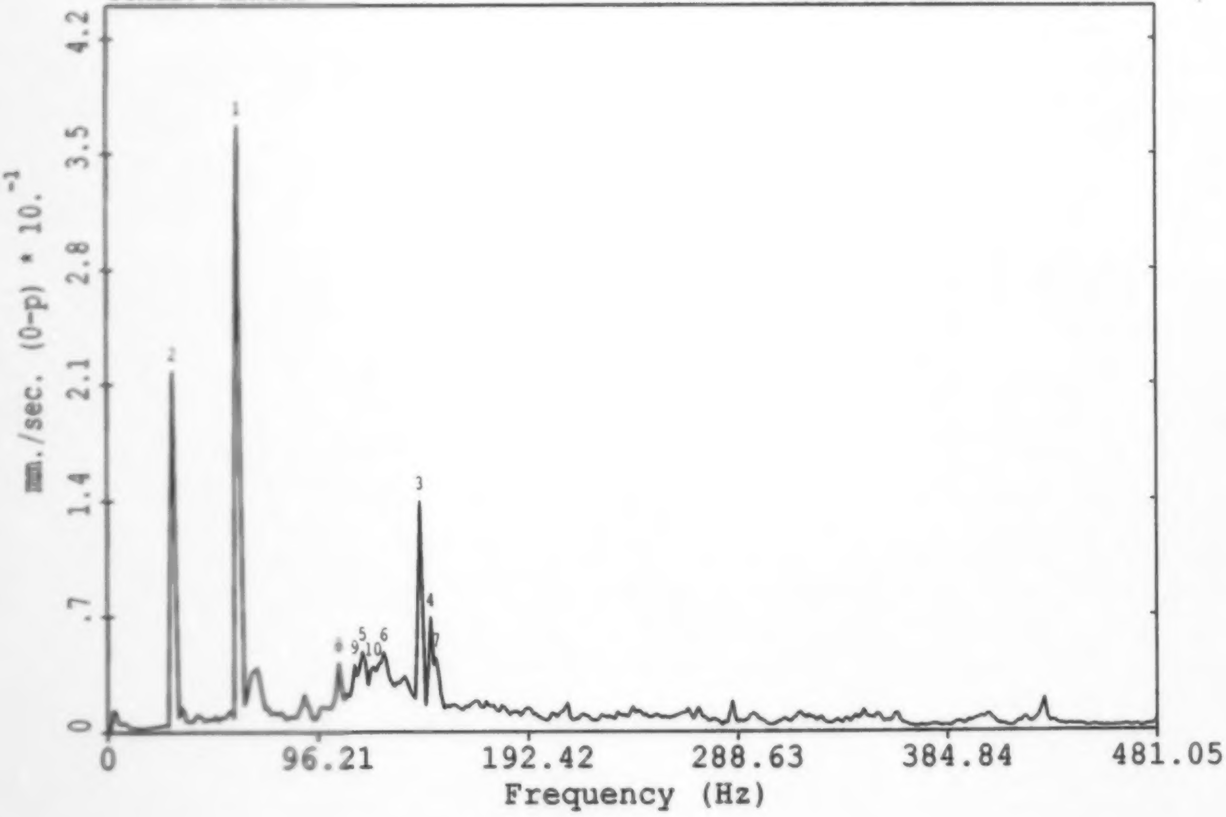


FIGURE B17

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. VERT
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	1.03
2	30.1	0.21
3	120.3	0.12
4	109.4	0.10
5	54.1	0.10
6	105.8	0.09
7	103.4	0.09
8	111.8	0.09
9	114.3	0.07
10	143.1	0.07

SCALE: Linear DATE: 19-FEB-88

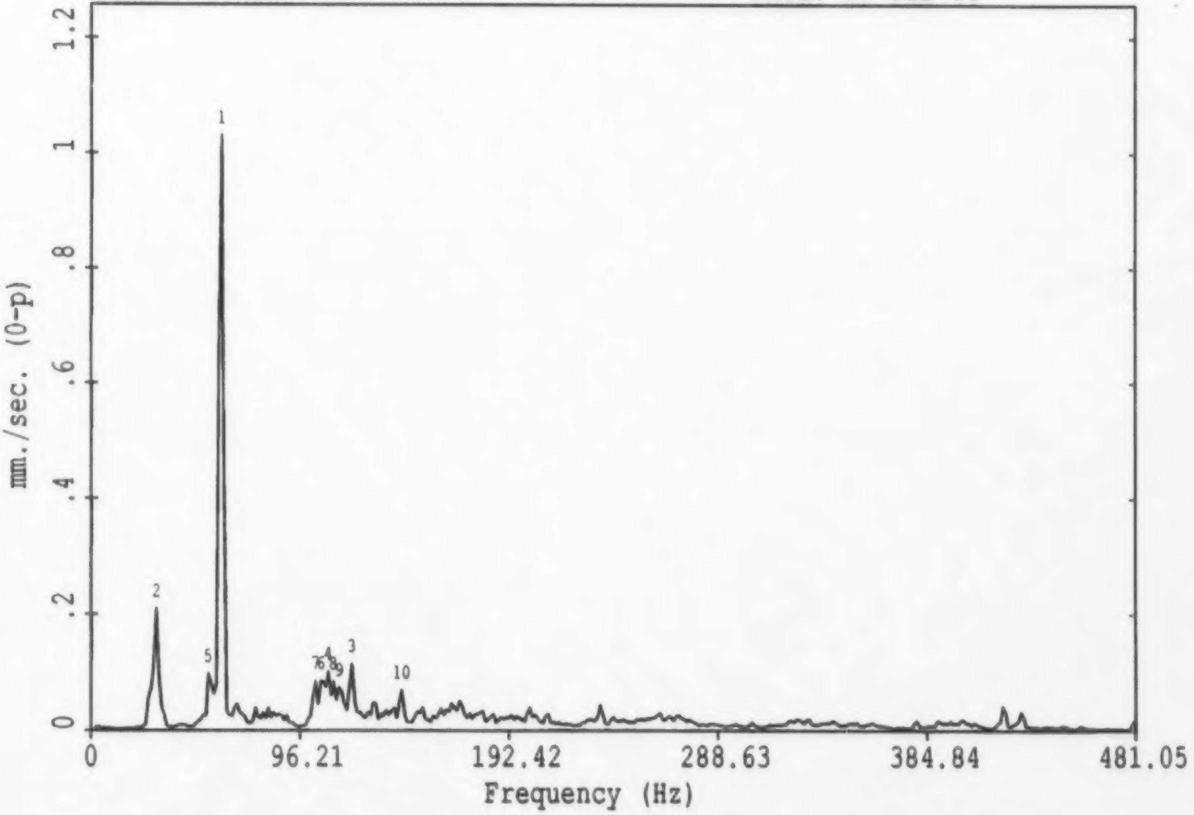


FIGURE B18

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. VERT
PROCESS CONDITION :- LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	1.82
2	120.3	0.20
3	30.1	0.16
4	27.7	0.11
5	55.3	0.10
6	419.7	0.09
7	210.5	0.06
8	67.3	0.06
9	143.1	0.06

SCALE: Linear DATE: 19-FEB-88

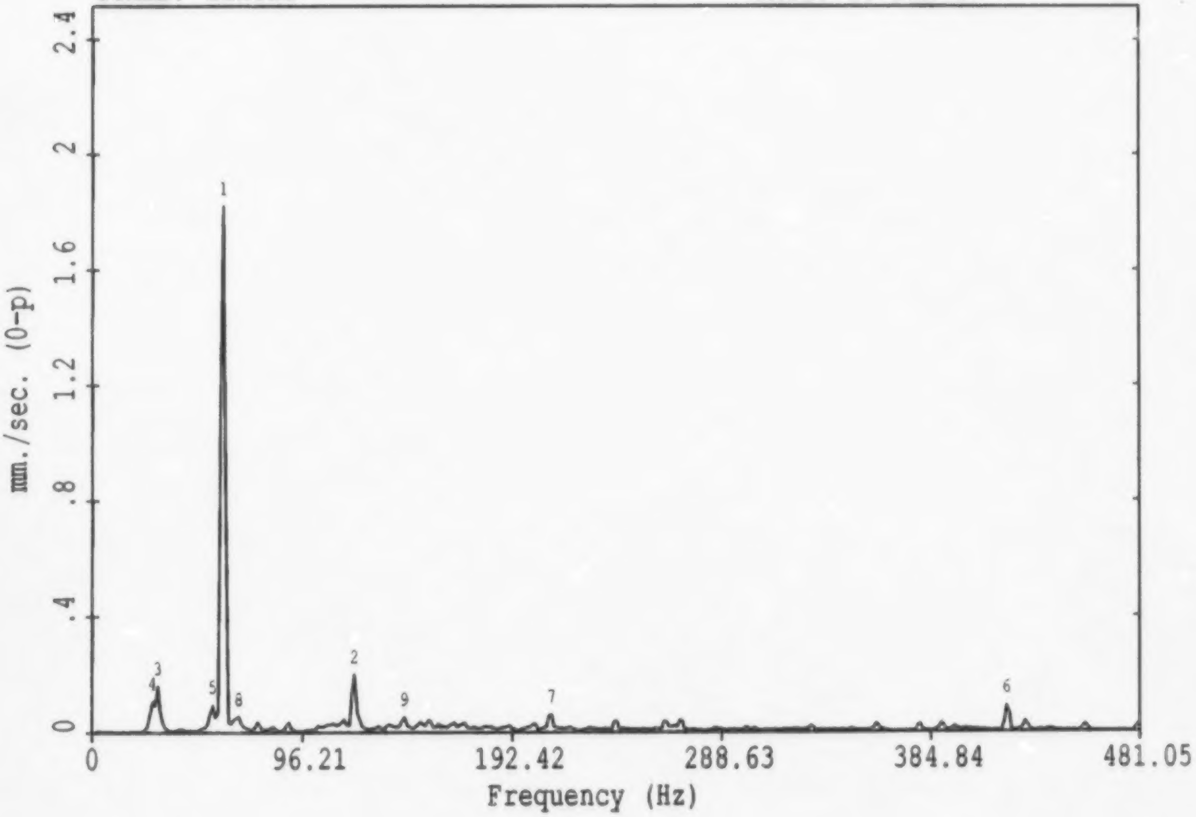


FIGURE B19

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. VERT
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	1.83
2	120.3	0.20
3	30.1	0.14
4	56.5	0.11
5	419.7	0.08
6	116.7	0.07
7	114.3	0.06
8	143.1	0.06
9	240.5	0.06
10	111.8	0.06

SCALE: Linear DATE: 19-FEB-88

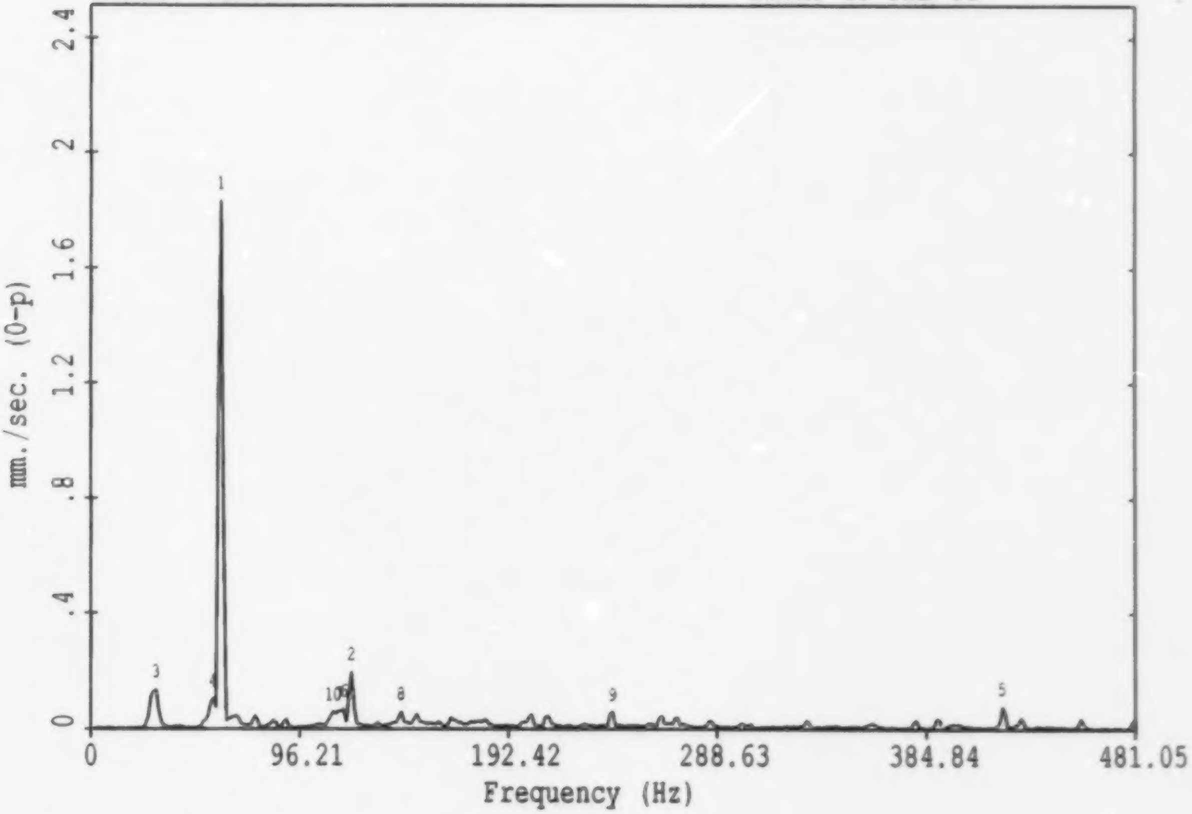


FIGURE B20

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. VERT
PROCESS CONDITION :- LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	1.56
2	180.4	0.20
3	120.3	0.20
4	240.5	0.10
5	203.2	0.10
6	419.7	0.08
7	329.5	0.08
8	157.5	0.07
9	30.1	0.07
10	75.8	0.07

SCALE: Linear

DATE: 19-FEB-88

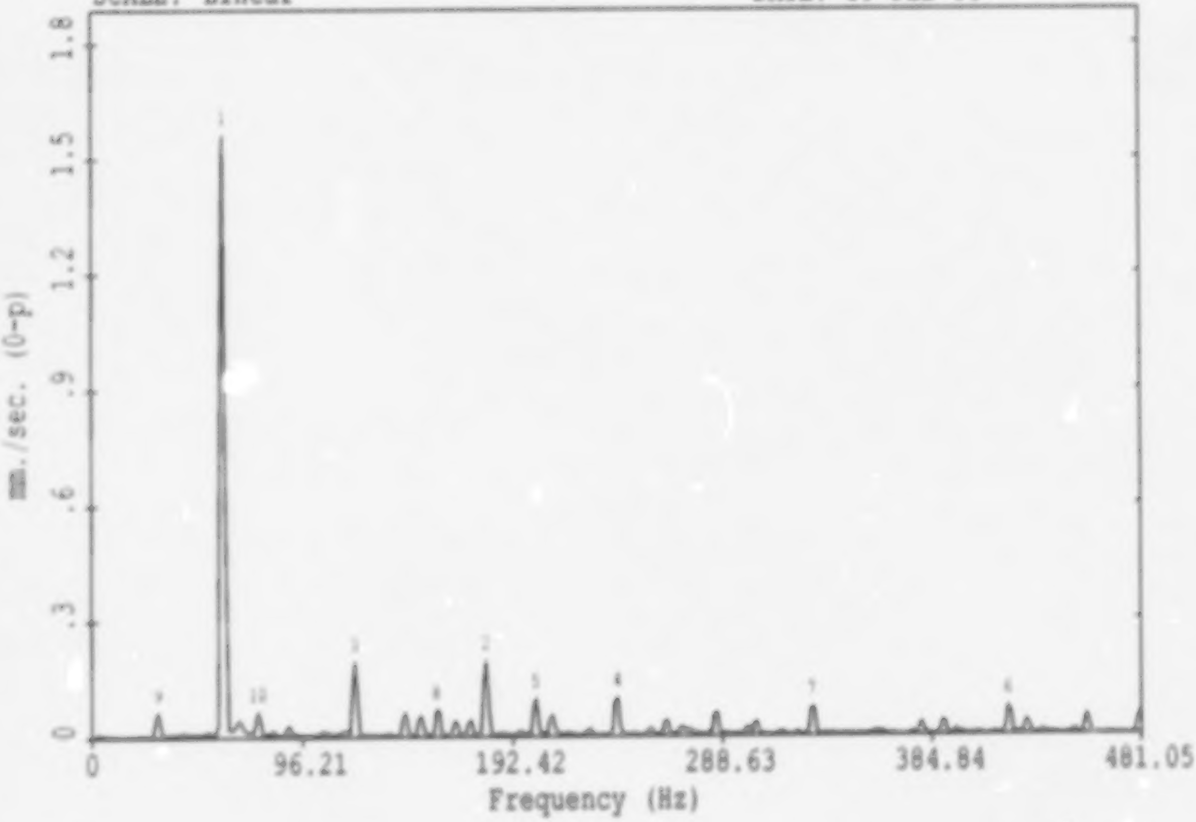
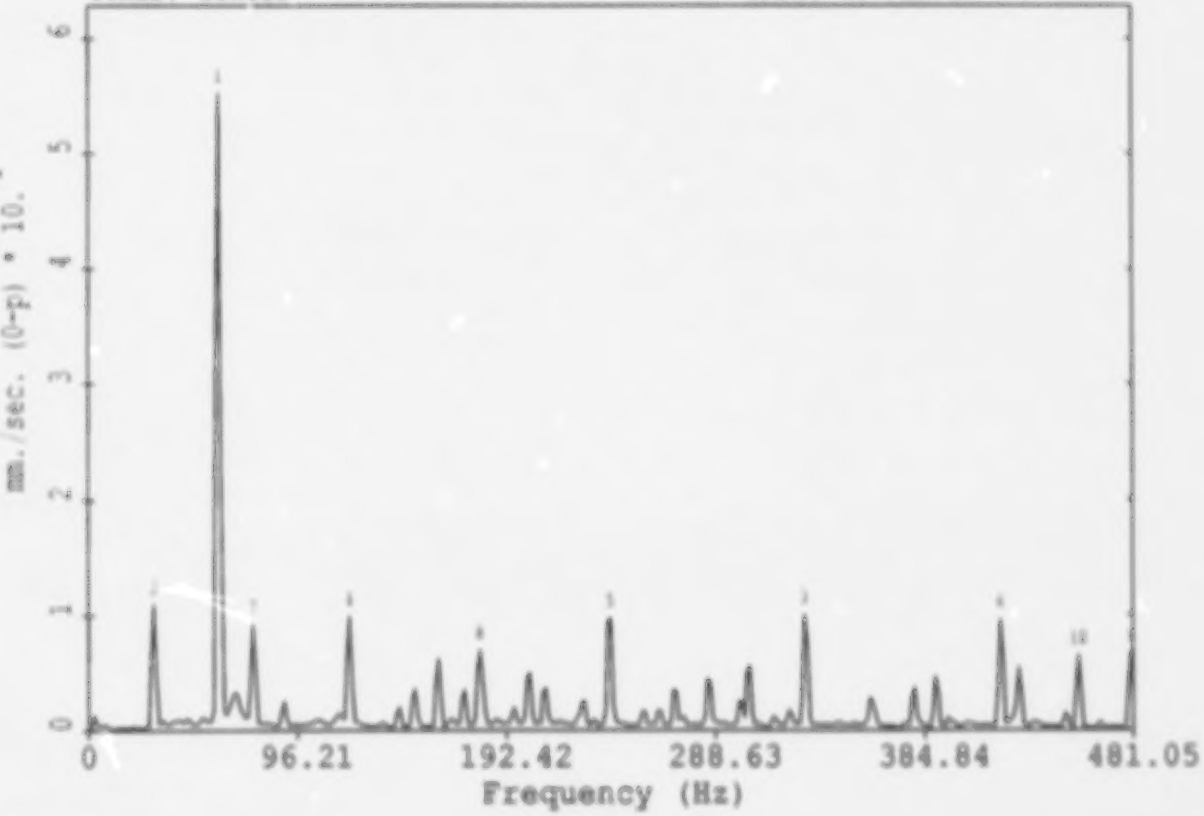


FIGURE B21

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. VERT
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.55
2	30.1	0.11
3	329.5	0.10
4	120.3	0.10
5	240.5	0.10
6	419.7	0.10
7	75.8	0.09
8	180.4	0.07
9	479.9	0.07
10	455.8	0.07



SCALE: Linear

DATE: 19-FEB-88

FIGURE B22

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. VERT
PROCESS CONDITION :- LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.30
2	30.1	0.13
3	240.5	0.11
4	329.5	0.10
5	419.7	0.10
6	75.8	0.10
7	479.9	0.07
8	304.3	0.07
9	455.8	0.07
10	180.4	0.07

SCALE: Linear

DATE: 19-FEB-88

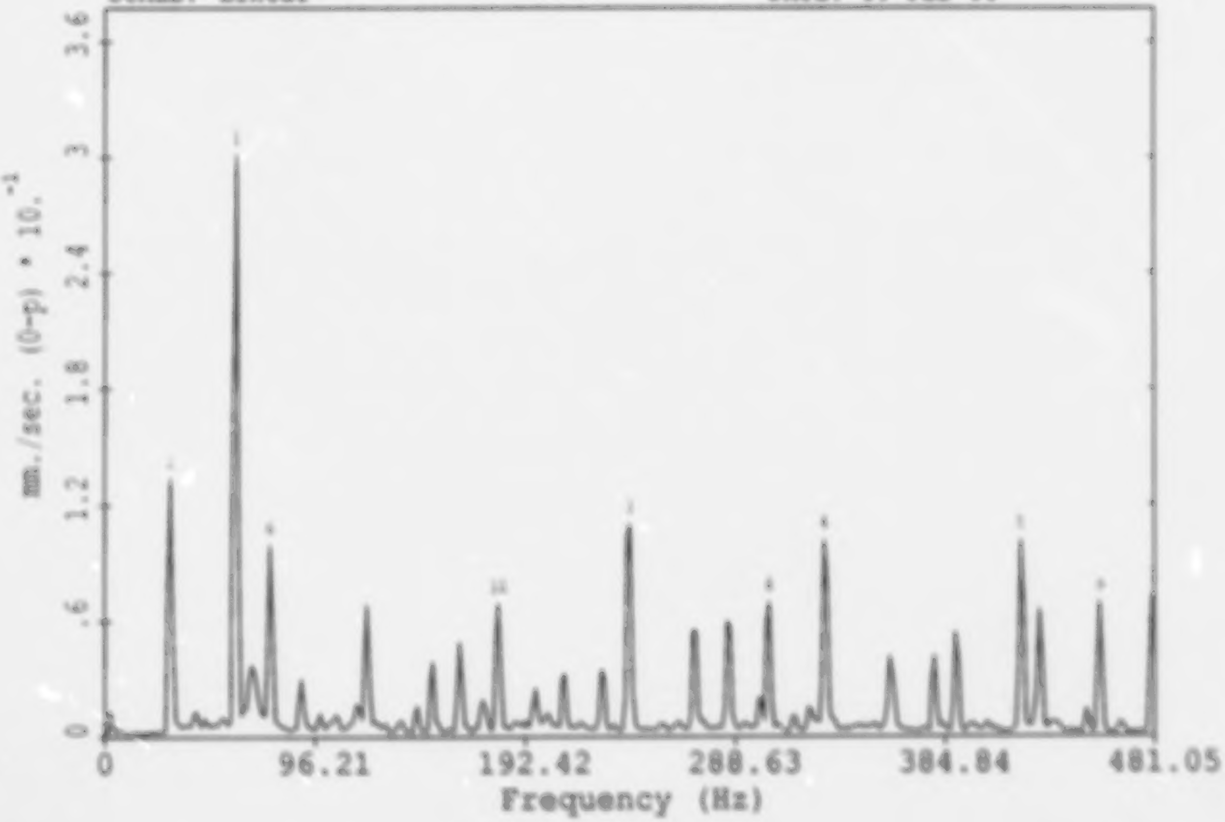


FIGURE B23

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. VERT
PROCESS CONDITION :- LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.29
2	30.1	0.18
3	240.5	0.13
4	75.8	0.11
5	329.5	0.11
6	180.4	0.11
7	419.7	0.10
8	304.3	0.09
9	286.2	0.07
10	479.9	0.07

SCALE: Linear

DATE: 19-FEB-88

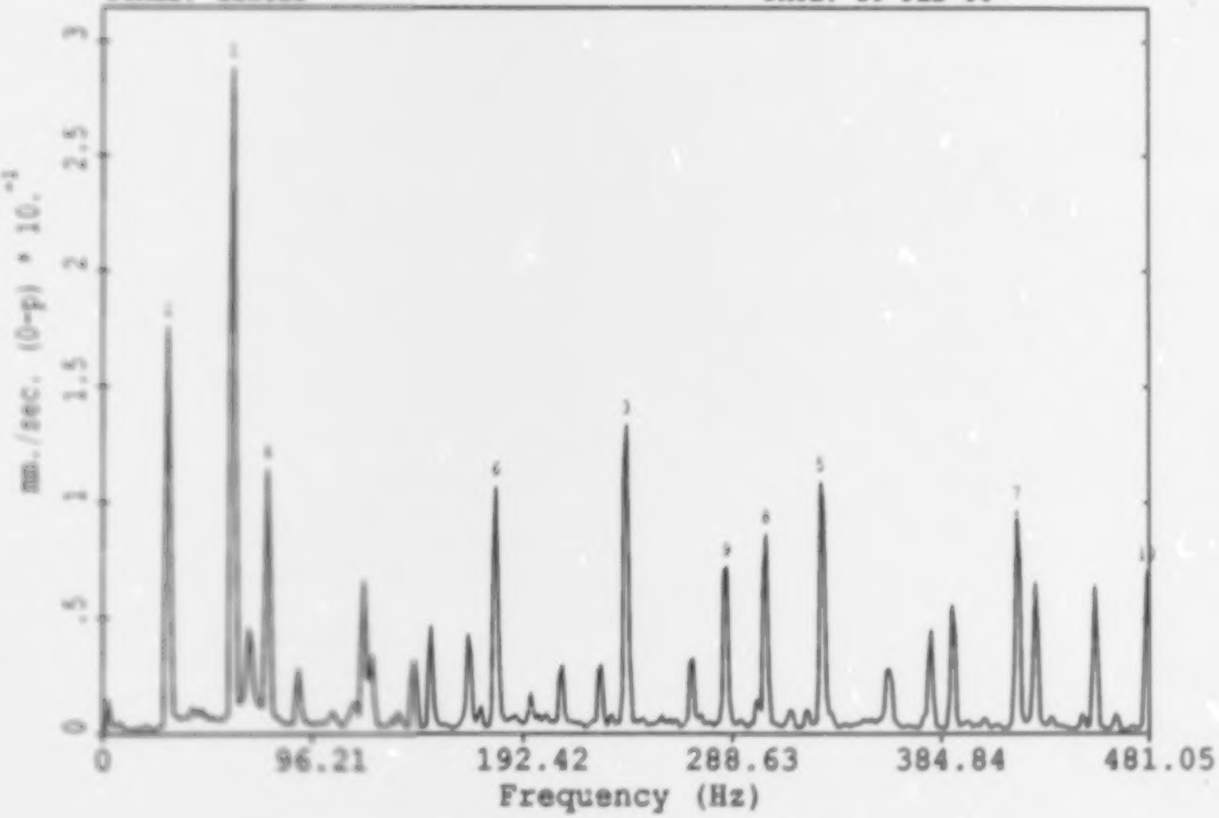


FIGURE B24

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. HOR.
PROCESS CONDITION :- LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	0.46
2	60.1	0.46
3	90.2	0.29
4	120.3	0.17
5	64.9	0.12
6	75.8	0.10
7	143.1	0.09
8	95.0	0.09
9	180.4	0.09
10	71.0	0.08

SCALE: Linear

DATE: 19-FEB-88

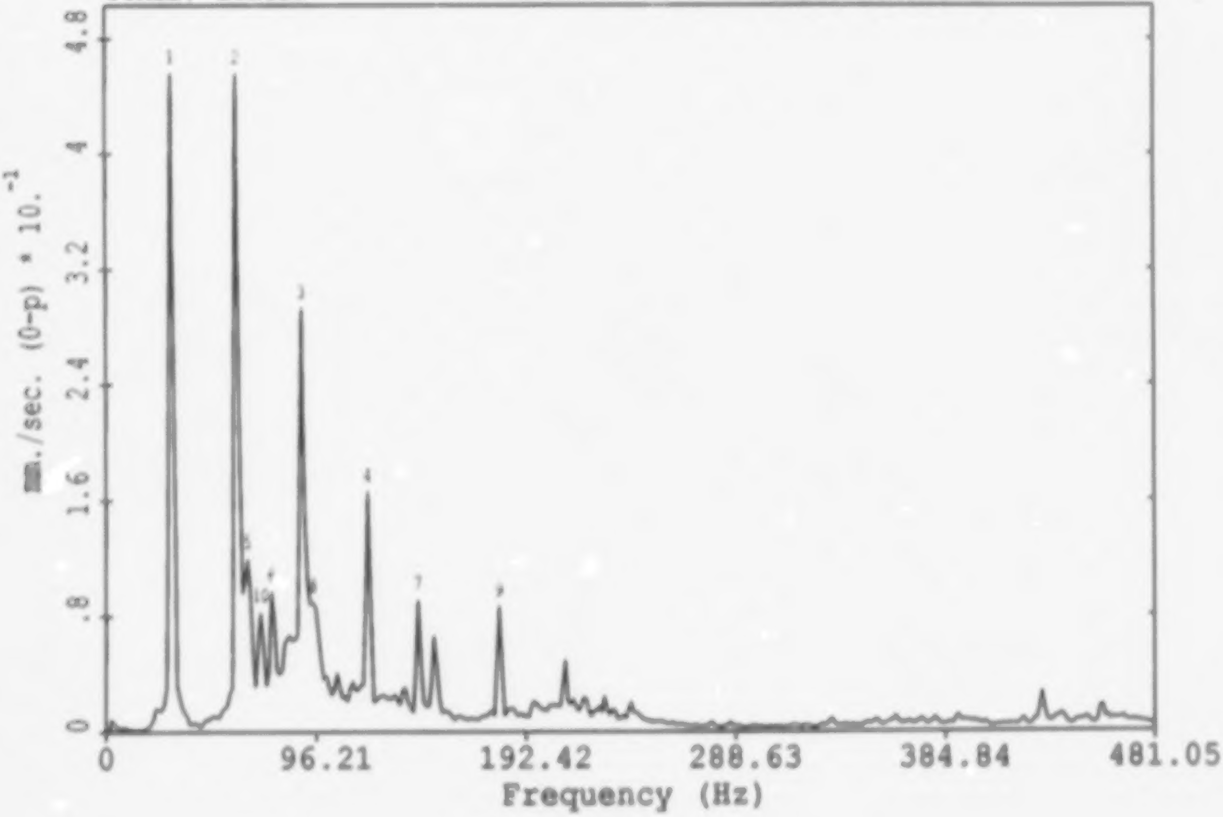


FIGURE B25

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. HOR.
PROCESS CONDITION :- LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	0.63
2	60.1	0.53
3	81.8	0.39
4	27.7	0.36
5	87.8	0.21
6	75.8	0.19
7	90.2	0.19
8	143.1	0.15
9	120.3	0.12
10	234.5	0.08

SCALE: Linear DATE: 19-FEB-88

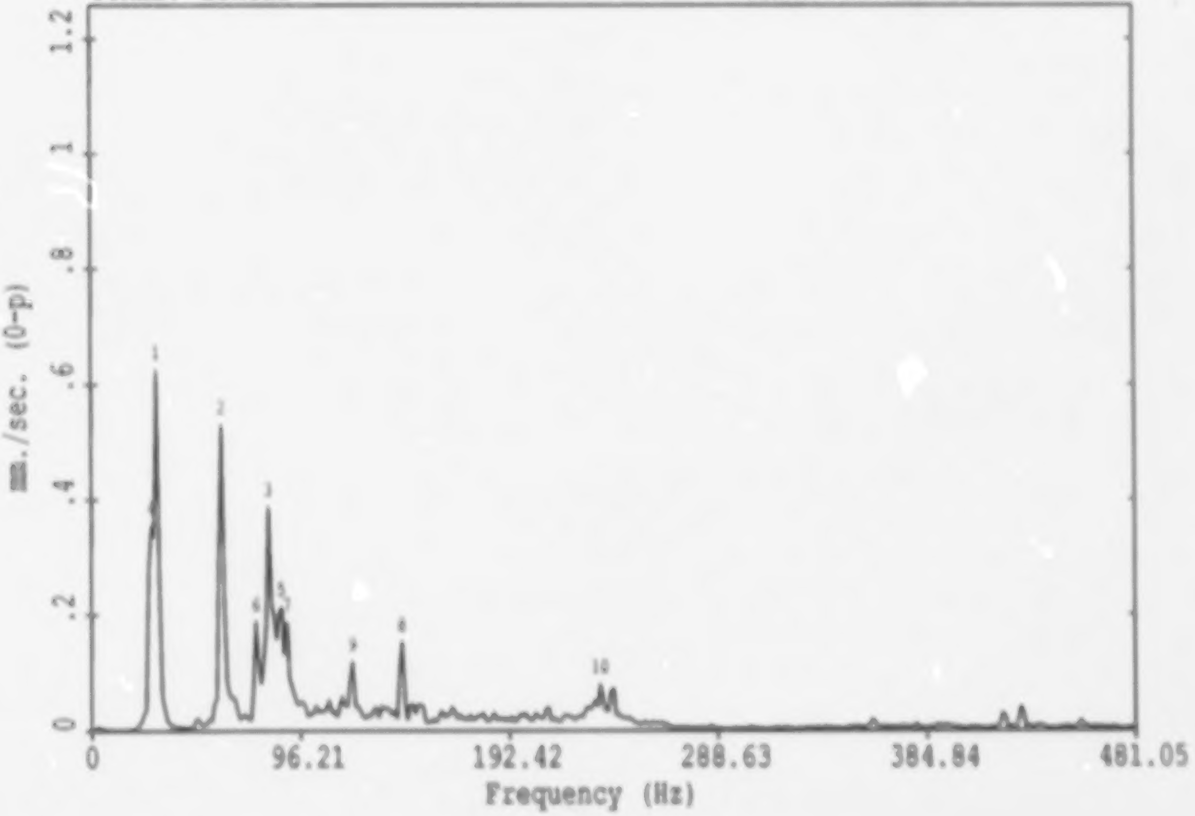


FIGURE B26

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	1.08
2	30.1	0.45
3	27.7	0.40
4	143.1	0.34
5	120.3	0.34
6	83.0	0.30
7	75.8	0.15
8	85.4	0.14
9	87.8	0.13
10	55.3	0.10

SCALE: Linear DATE: 19-FEB-88

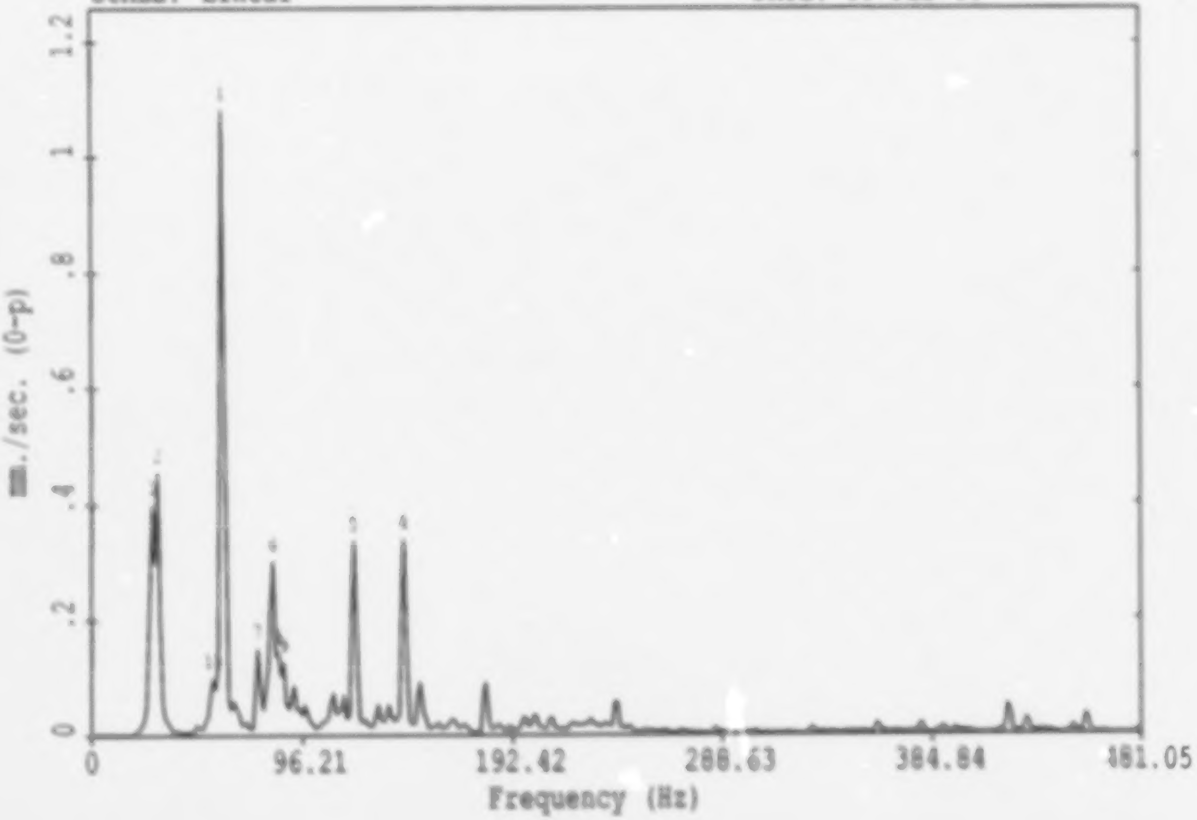
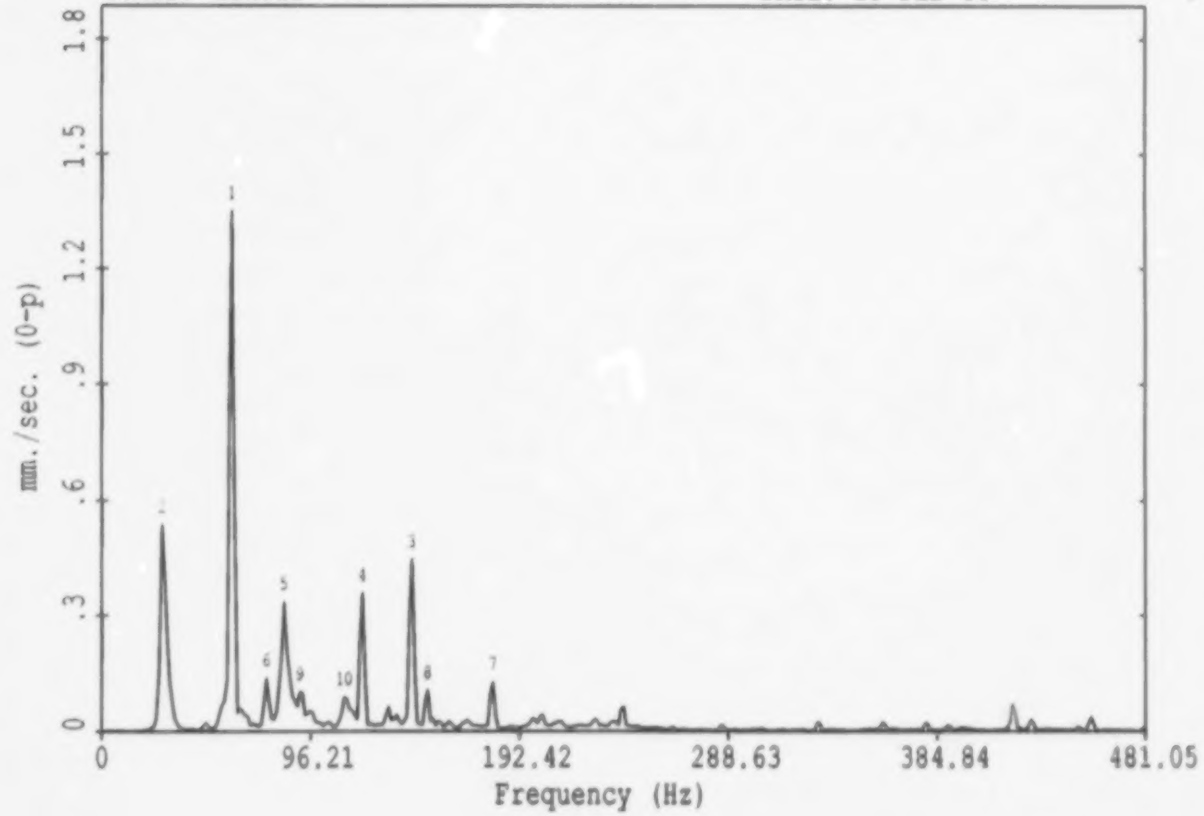


FIGURE B27

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. HOR.
PROCESS CONDITION :- LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	1.35
2	27.7	0.54
3	143.1	0.45
4	120.3	0.36
5	84.2	0.34
6	75.8	0.14
7	180.4	0.13
8	150.3	0.11
9	91.4	0.10
10	111.8	0.09



SCALE: Linear

DATE: 19-FEB-88

FIGURE B28

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. HOR.
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	1.60
2	143.1	0.64
3	30.1	0.43
4	120.3	0.32
5	75.8	0.14
6	150.3	0.12
7	203.2	0.10
8	83.0	0.09
9	419.7	0.09
10	90.2	0.07

SCALE: Linear DATE: 19-FEB-88

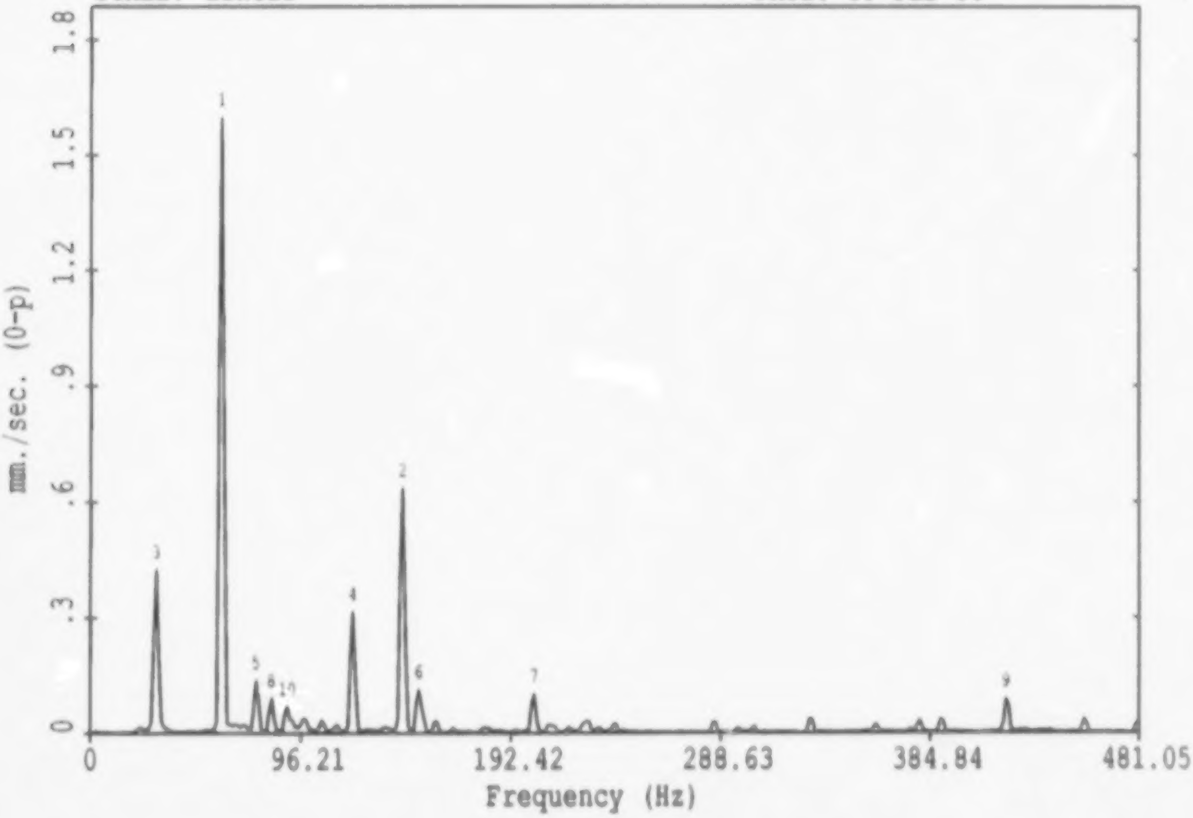


FIGURE B29

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.69
2	60.1	0.39
3	30.1	0.33
4	120.3	0.25
5	180.4	0.17
6	75.8	0.15
7	150.3	0.10
8	240.5	0.07
9	161.2	0.07
10	419.7	0.07

SCALE: Linear

DATE: 19-FEB-88

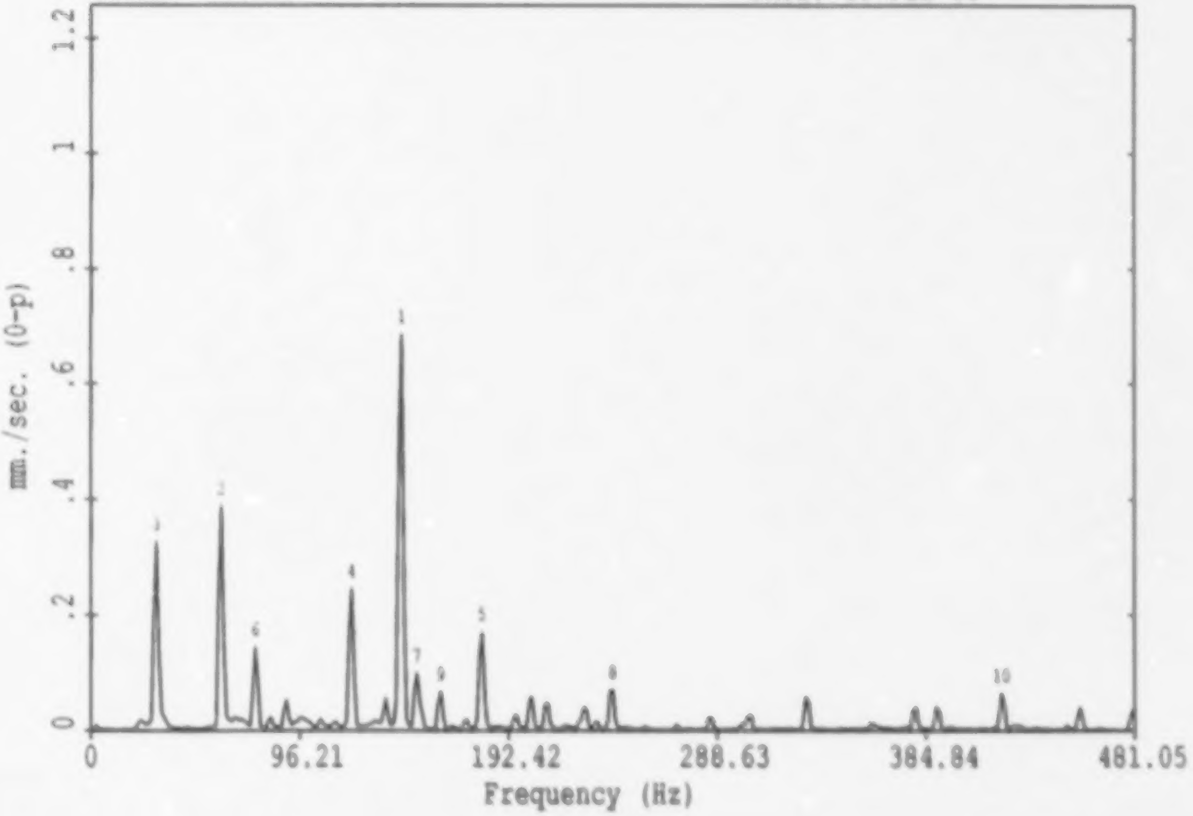


FIGURE B30

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR IB BRG CASING VEL. HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.70
2	60.1	0.42
3	30.1	0.38
4	120.3	0.19
5	75.8	0.14
6	180.4	0.10
7	240.5	0.09
8	210.5	0.09
9	150.3	0.08
10	135.9	0.07

SCALE: Linear DATE: 19-FEB-88

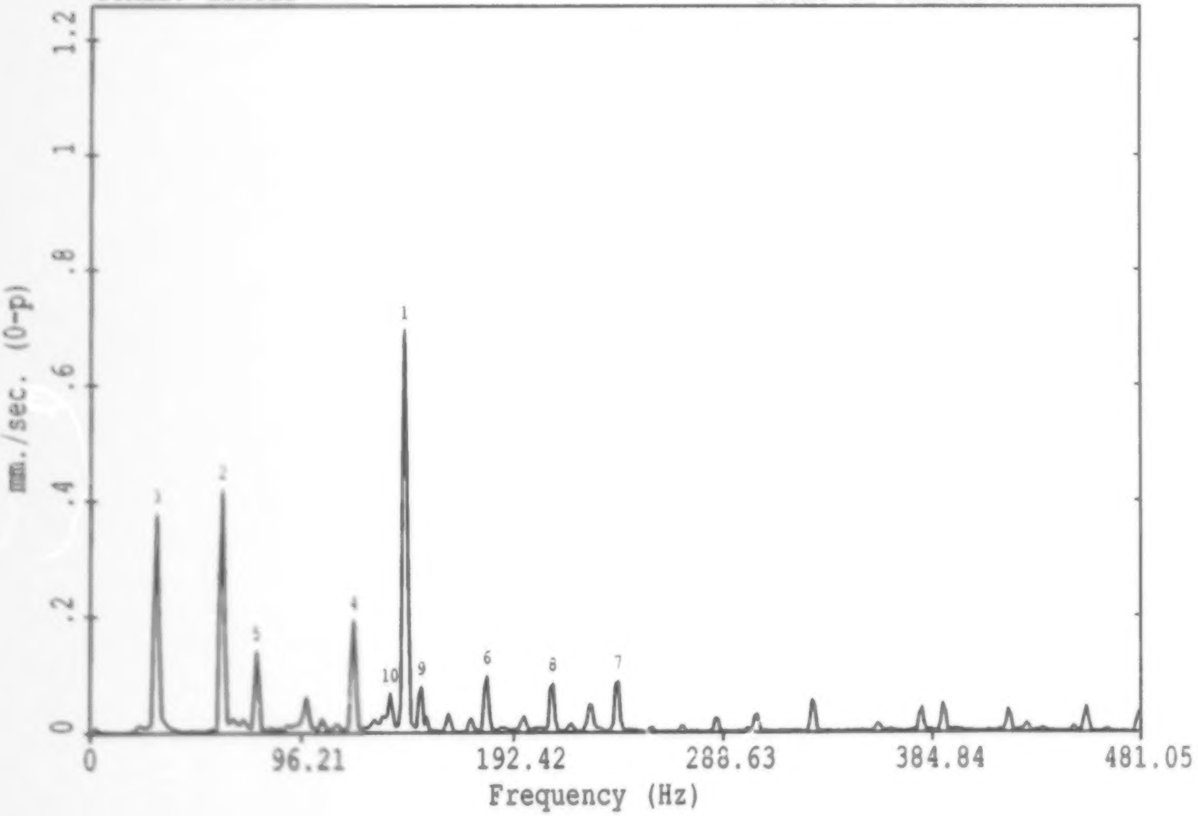


FIGURE B31

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL	: AC GENERATOR IB BRG CASING VEL. HOR.
PROCESS CONDITION	: LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.69
2	30.1	0.63
3	60.1	0.41
4	120.3	0.17
5	75.8	0.13
6	150.3	0.11
7	210.5	0.10
8	240.5	0.09
9	135.9	0.08
10	180.4	0.08

SCALE: Linear

DATE: 19-FEB-88

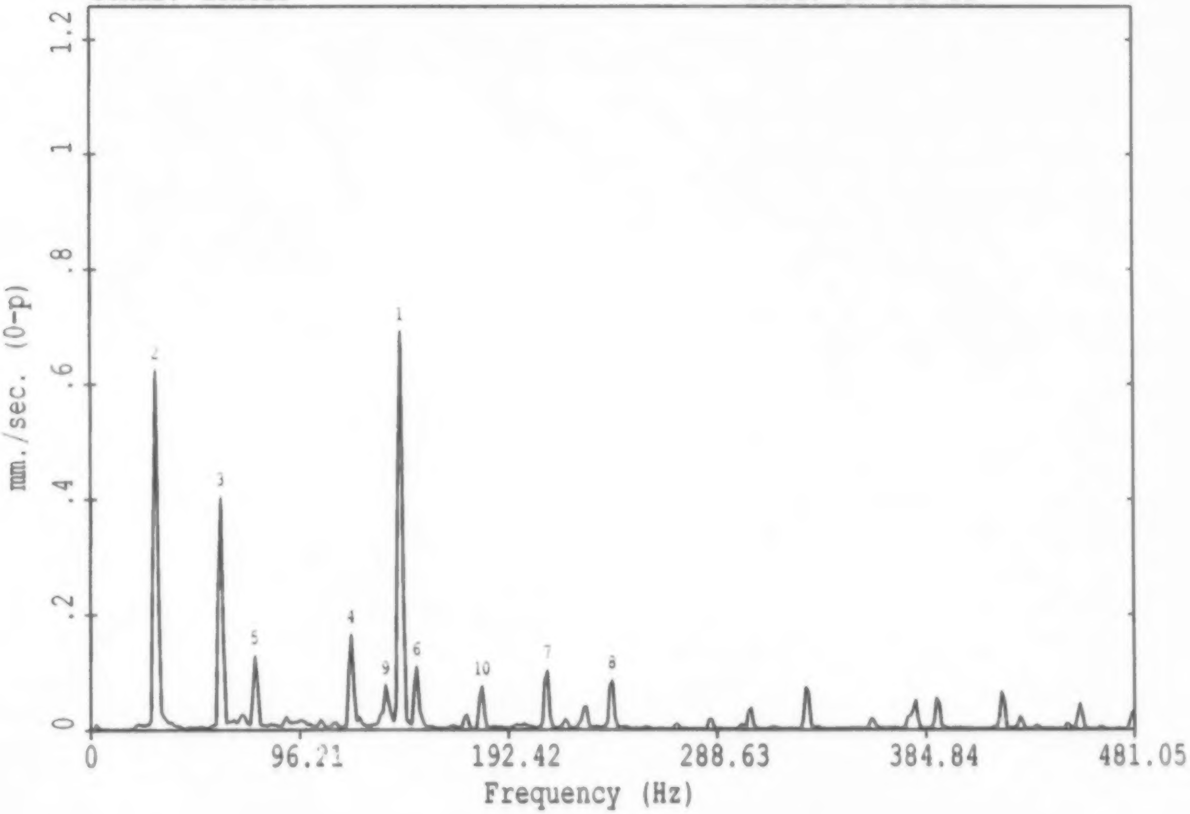
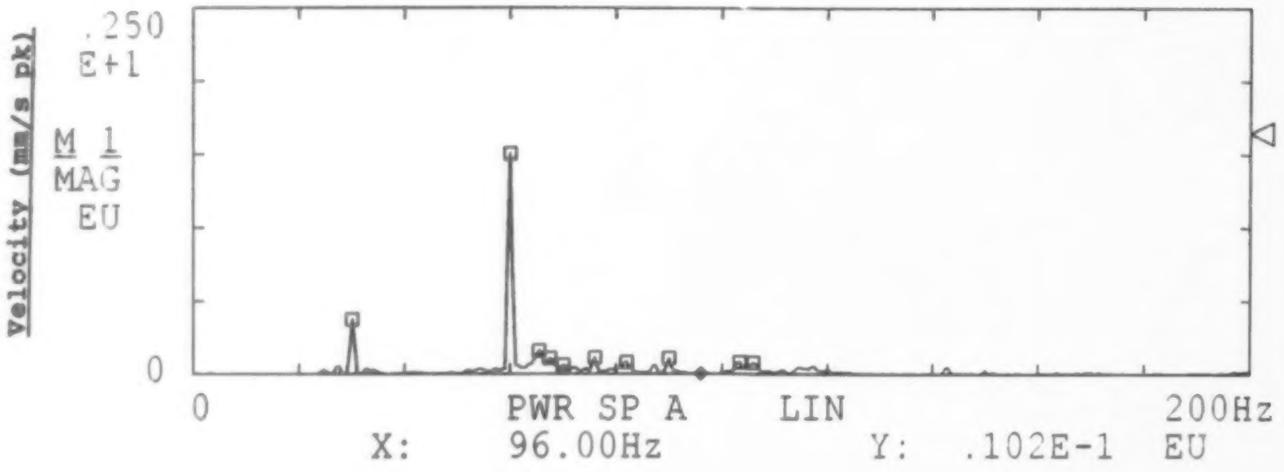


FIGURE B32

```
DNGS EPG2 AC GEN IB  AXI VEL  0  MW              01:16
  500Hz A:AC/  2V  B:AC/ 50V   INST    0/16    DUAL 1k

                   PWR SPECTRUM  ChA
         1          60.00Hz        .152E+1  EU
         2          30.00           .383E+0
         3          65.50           .170E+0
         4          76.00           .119E+0
         5          67.50           .110E+0
         6          90.00           .111E+0
         7          82.00           .920E-1
         8         103.50           .934E-1
         9         106.00           .859E-1
        10          70.00           .631E-1
```

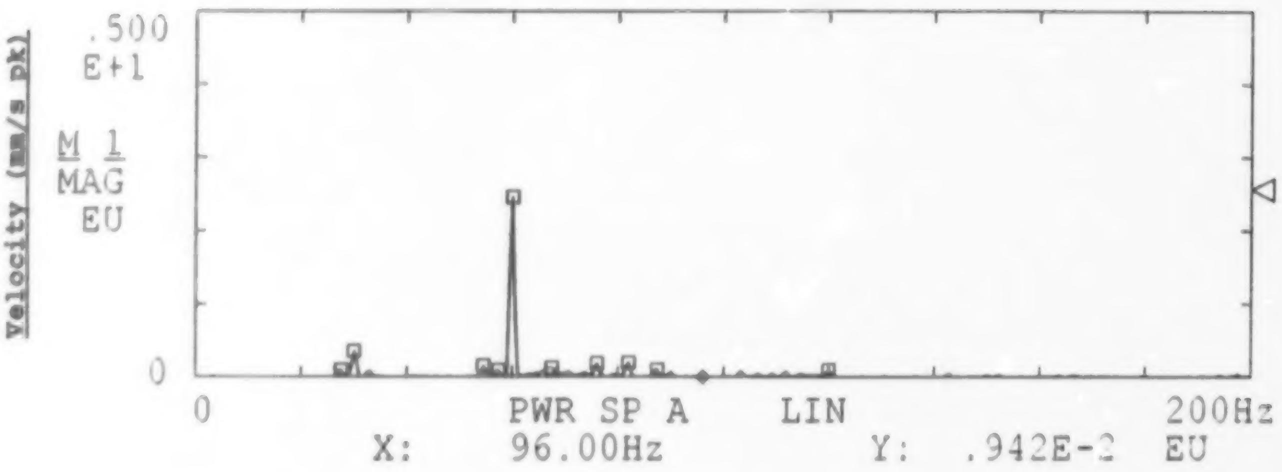


00:33

FIGURE B33

```
DNGS EPG2 AC GEN IB  AXI VEL  1.0  MW              01:11
  500Hz A:AC/  2V  B:AC/ 50V   INST    0/16    DUAL 1k

                 PWR SPECTRUM  ChA
         1        60.00Hz       .247E+1  EU
         2        30.00         .363E+0
         3        82.00         .208E+0
         4        76.00         .200E+0
         5        54.50         .162E+0
         6        67.50         .134E+0
         7        87.50         .118E+0
         8        27.50         .106E+0
         9        57.50         .104E+0
        10       120.00         .109E+0
```

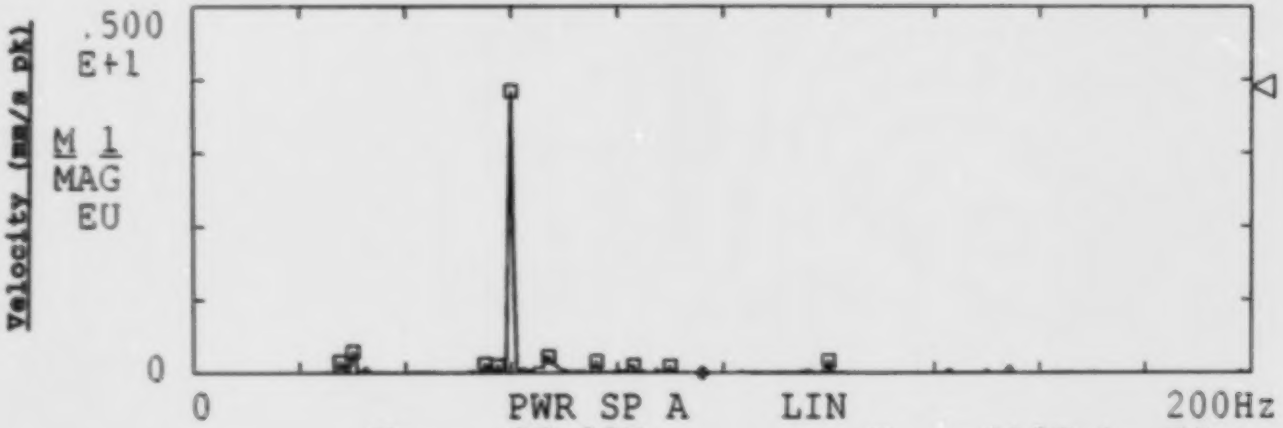


00:31

FIGURE B34

```
DNGS EPG2 AC GEN IB  AXI VEL  1.5  MW              01:09
  500Hz A:AC/  2V  B:AC/ 50V   INST    0/16    DUAL 1k

                      PWR SPECTRUM  ChA
              1        60.00Hz        .386E+1  EU
              2        30.00          .298E+0
              3        67.00          .244E+0
              4       120.00          .181E+0
              5        27.50          .164E+0
              6        76.00          .169E+0
              7        55.00          .125E+0
              8        57.50          .111E+0
              9        83.00          .118E+0
             10        90.00          .100E+0
```



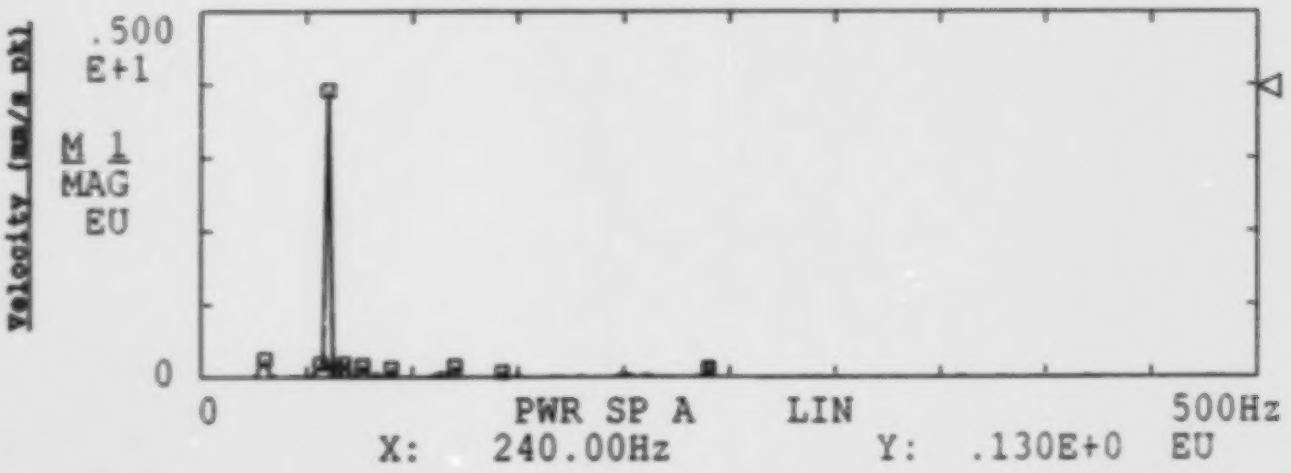
```
X:    96.00Hz           Y:  .113E-1  EU
```

00:30

FIGURE B35

```
DNGS EPG2 AC GEN IB  AXI VEL  2.0  MW              01:06
  500Hz A:AC/  2V  B:AC/ 50V   INST    0/16    DUAL 1k

                    PWR SPECTRUM  ChA
             1        60.00Hz         .393E+1  EU
             2        30.00           .252E+0
             3        56.25           .193E+0
             4        67.50           .196E+0
             5        76.25           .184E+0
             6       120.00           .161E+0
             7        63.75           .132E+0
             8        90.00           .137E+0
             9       240.00           .130E+0
            10       142.50           .928E-1
```

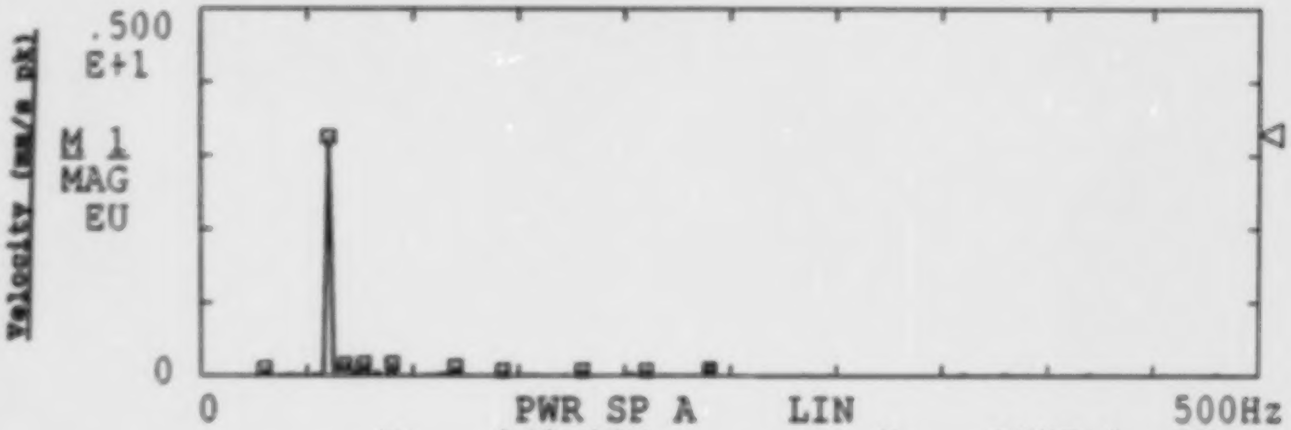


00:25

FIGURE B36

```
DNGS EPG2 AC GEN IB  AXI VEL  3.0  MW              01:00
  500Hz A:AC/  2V  B:AC/ 50V   INST    0/16    DUAL 1k

                    PWR SPECTRUM  ChA
            1        60.00Hz        .327E+1  EU
            2        76.25          .183E+0
            3        90.00          .179E+0
            4        67.50          .162E+0
            5       120.00          .136E+0
            6        30.00          .117E+0
            7       240.00          .103E+0
            8       142.50          .804E-1
            9       180.00          .904E-1
           10       210.00          .808E-1
```



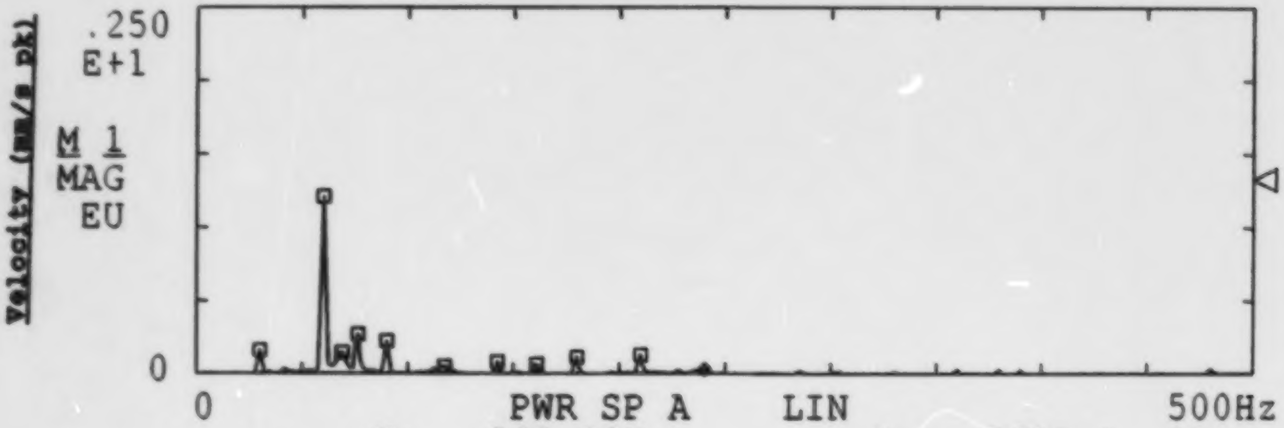
```
           X:   240.00Hz          Y:  .103E+0   EU

                                                     00:24
```

FIGURE B37

```
DNGS EPG2 AC GEN IB  AXI VEL  4.0  MW               00:57
  500Hz A:AC/  2V  B:AC/ 50V   INST    0/16    DUAL 1k

                  PWR SPECTRUM  ChA
        1          60.00Hz        .121E+1  EU
        2          76.25          .274E+0
        3          90.00          .230E+0
        4          30.00          .168E+0
        5          68.75          .154E+0
        6         210.00          .133E+0
        7         180.00          .118E+0
        8         142.50          .924E-1
        9         161.25          .736E-1
       10         117.50          .568E-1
```



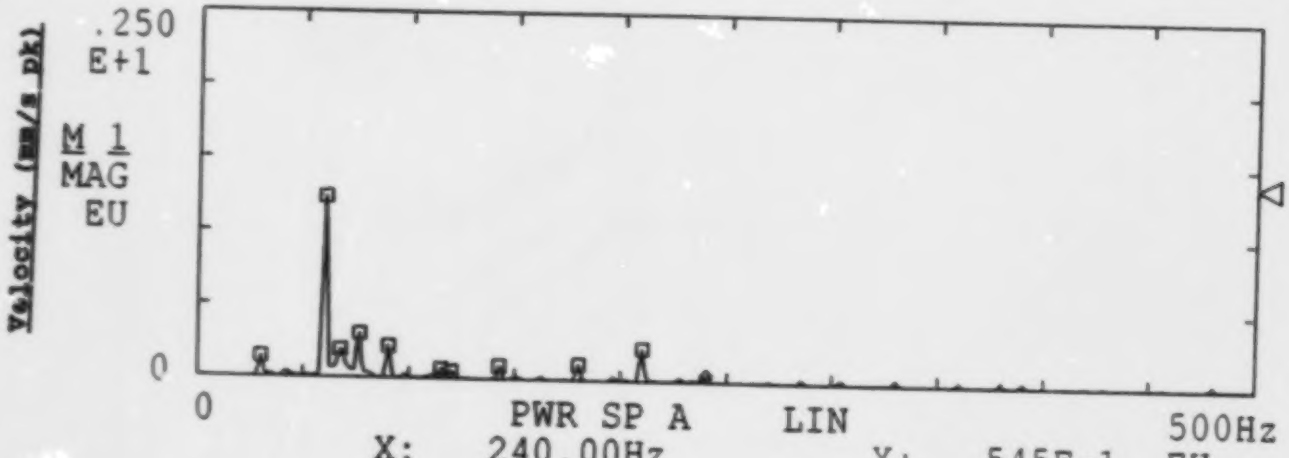
```
X:   240.00Hz            Y:  .361E-1  EU
```

00:23

FIGURE B38

```
DNGS EPG2 AC GEN IB  AXI VEL  5.0  MW                    00:56
  500Hz A:AC/  2V  B:AC/ 50V   INST    0/16    DUAL 1k

                PWR SPECTRUM  ChA
         1       60.00Hz        .124E+1  EU
         2       76.25          .308E+0
         3      210.00          .231E+0
         4       90.00          .222E+0
         5       67.50          .199E+0
         6       30.00          .147E+0
         7      180.00          .110E+0
         8      142.50          .981E-1
         9      115.00          .727E-1
        10      120.00          .613E-1
```



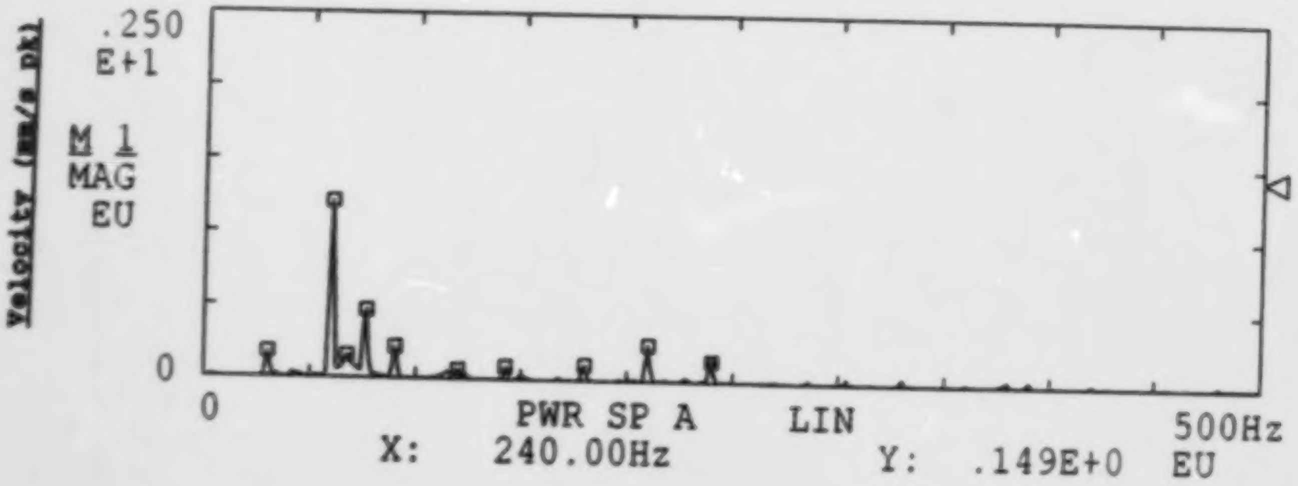
```
        X:   240.00Hz                Y:  .545E-1  EU

                                                            00:22
```

FIGURE B39

```
DNGS EPG2 AC GEN IB  AXI VEL  6.8  MW              00:53
  500Hz A:AC/  2V  B:AC/ 50V   INST     0/16     DUAL 1k

                    PWR SPECTRUM  ChA
            1         60.00Hz        .122E+1  EU
            2         76.25          .474E+0
            3        210.00          .252E+0
            4         90.00          .225E+0
            5         30.00          .182E+0
            6         67.50          .163E+0
            7        240.00          .149E+0
            8        180.00          .116E+0
            9        142.50          .990E-1
           10        120.00          .774E-1
```



```
          X:   240.00Hz            Y:  .149E+0  EU
```

00:20

FIGURE B40

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG VERT.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	27.15
2	30.1	20.29
3	120.3	4.55
4	90.2	3.93
5	180.4	1.81
6	300.7	1.63
7	210.5	1.49
8	270.6	1.47
9	240.5	1.35
10	360.8	0.97

SCALE: Linear DATE: 19-FEB-88

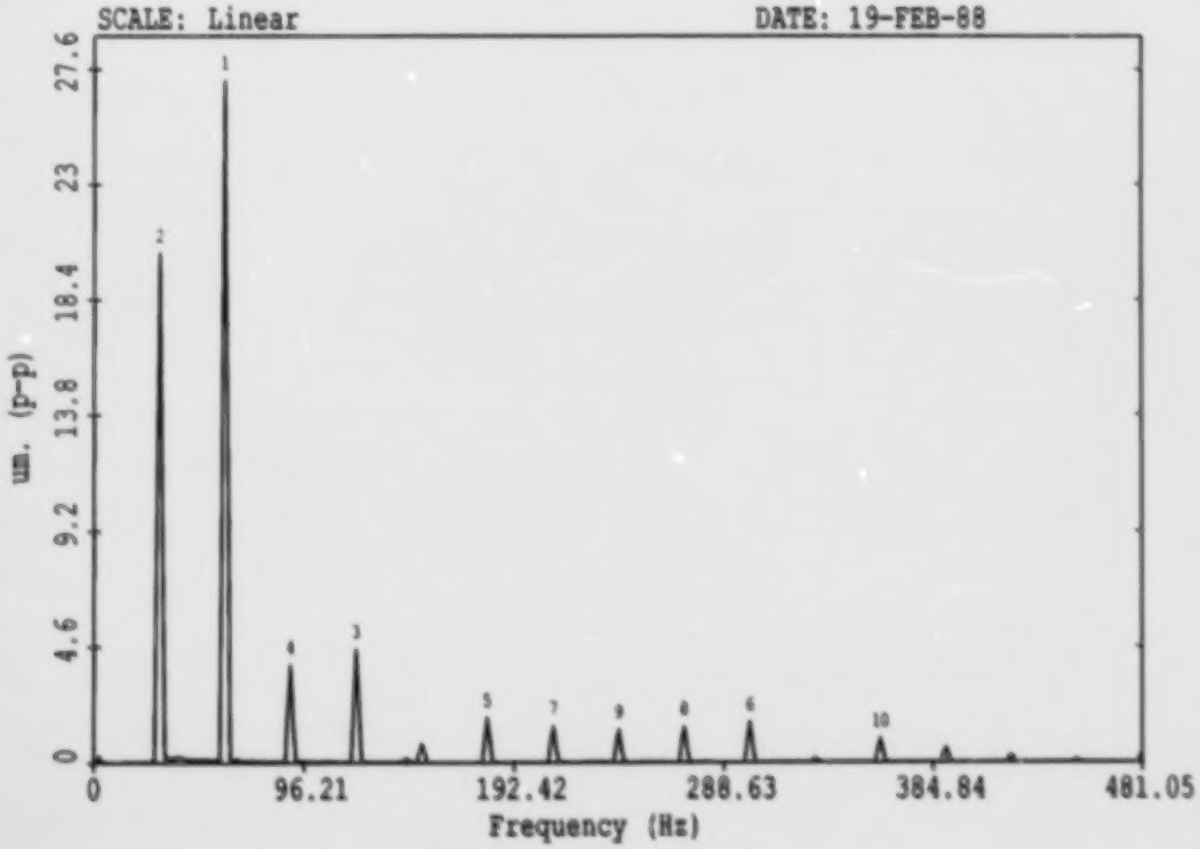


FIGURE B41

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG VERT.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	26.84
2	30.1	19.17
3	120.3	4.43
4	90.2	4.18
5	180.4	1.80
6	210.5	1.51
7	299.5	1.44
8	270.6	1.32
9	240.5	1.19
10	359.6	0.84

SCALE: Linear DATE: 19-FEB-88

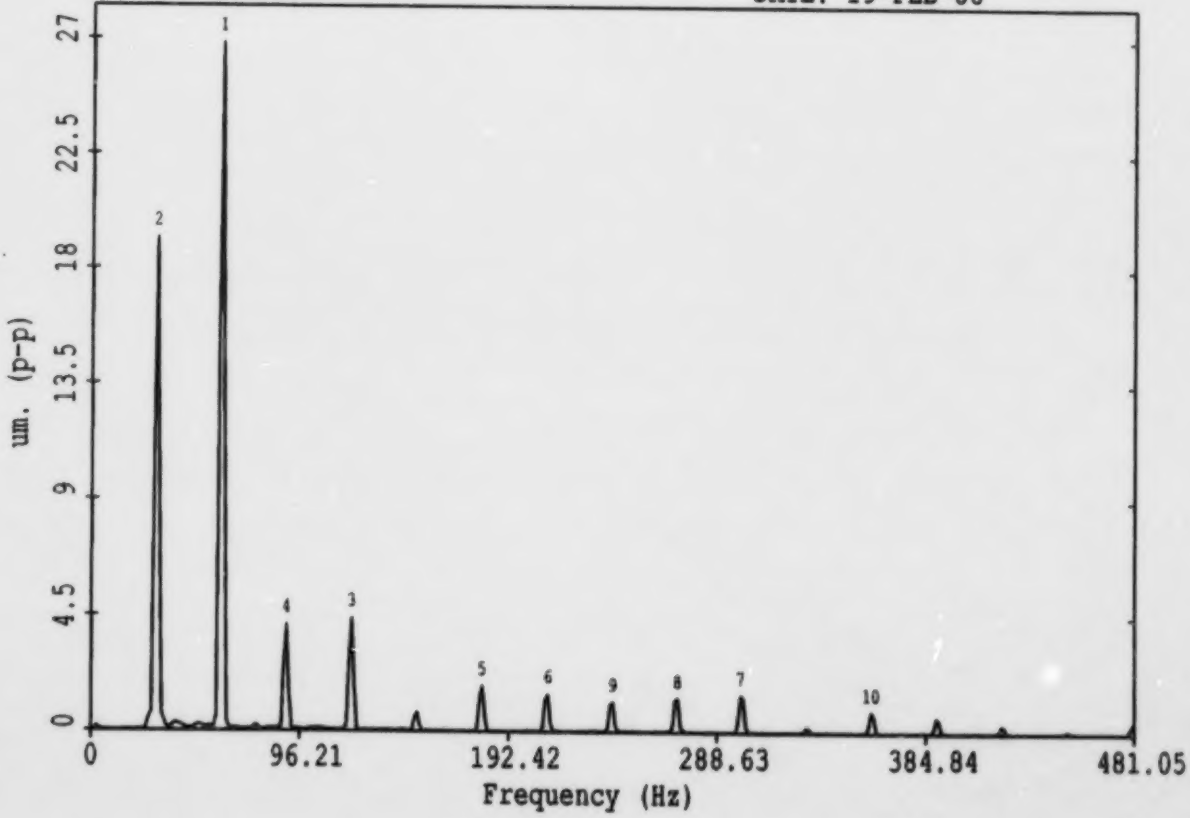


FIGURE B42

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	27.70
2	30.1	17.30
3	120.3	4.36
4	90.2	4.29
5	180.4	1.68
6	299.5	1.37
7	210.5	1.28
8	269.4	1.23
9	359.6	0.91
10	240.5	0.88

SCALE: Linear DATE: 19-FEB-88

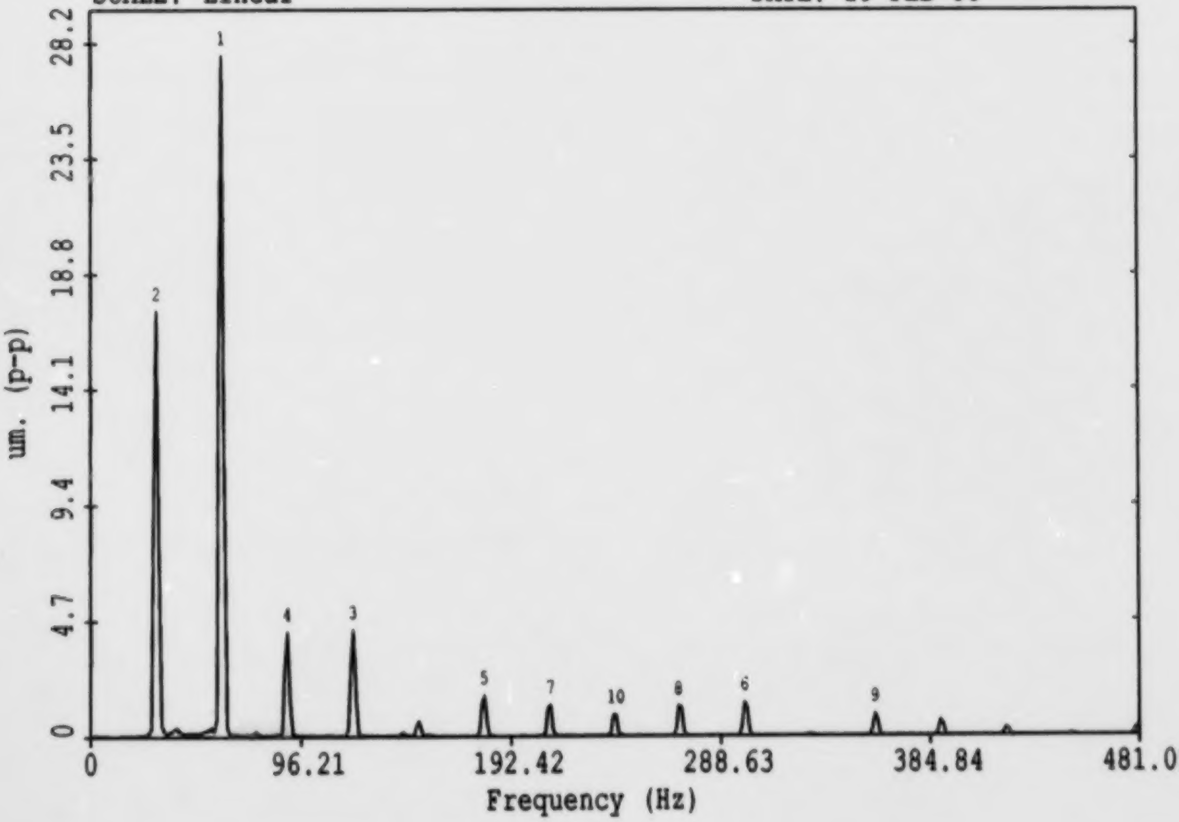


FIGURE B43

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG VERT.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	28.16
2	30.1	15.78
3	90.2	4.17
4	120.3	4.14
5	180.4	1.76
6	210.5	1.42
7	299.5	1.41
8	269.4	1.37
9	240.5	0.95
10	359.6	0.92

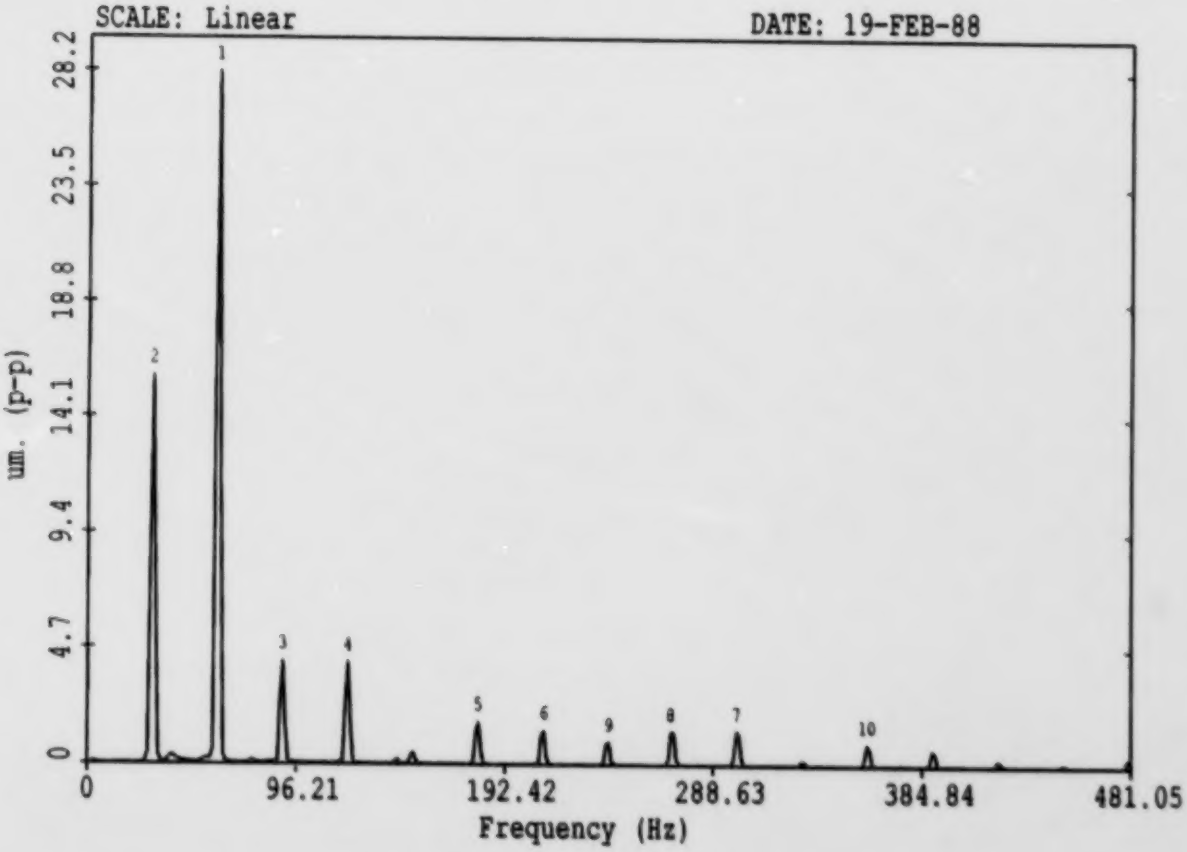


FIGURE B44

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG VERT.
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	29.09
2	30.1	14.65
3	120.3	4.48
4	90.2	4.17
5	180.4	1.85
6	210.5	1.78
7	270.6	1.69
8	300.7	1.37
9	240.5	1.32
10	359.6	0.92

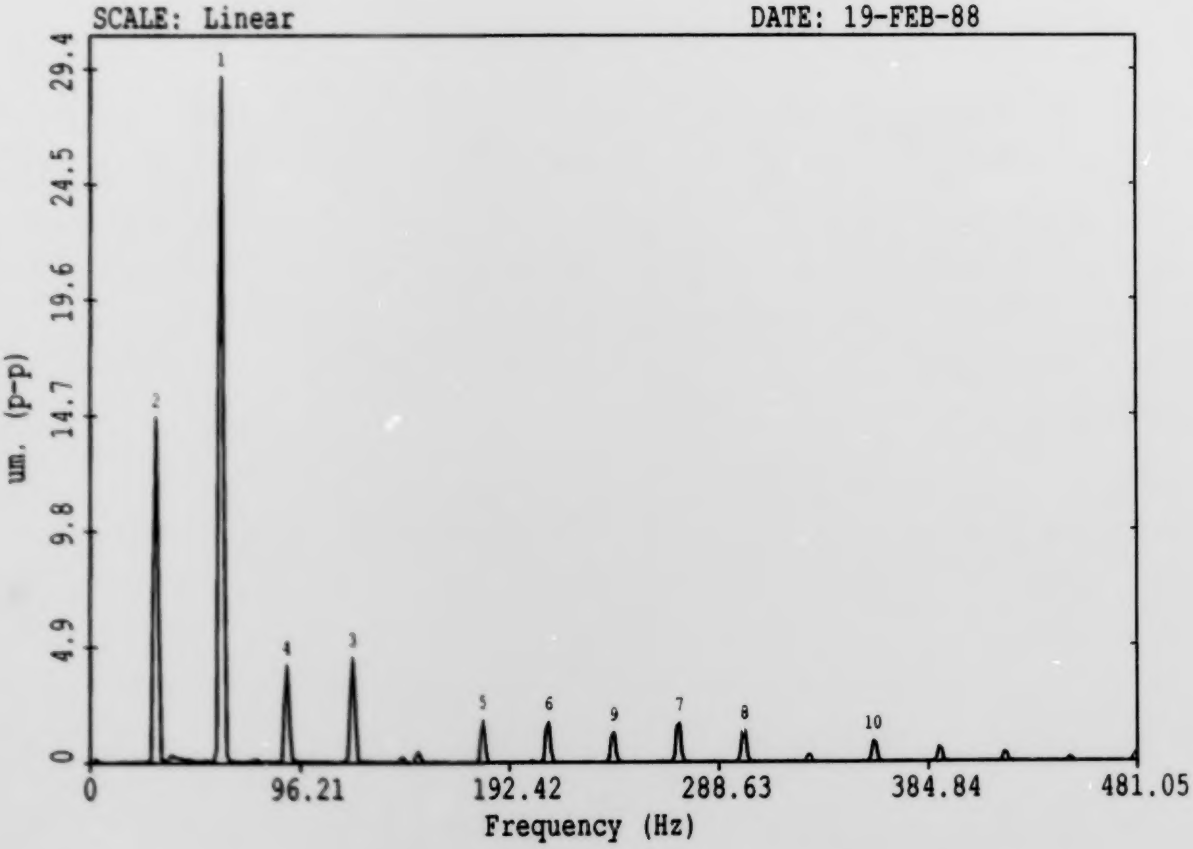


FIGURE B45

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG VERT.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	27.01
2	30.1	14.62
3	120.3	4.36
4	90.2	4.24
5	180.4	1.88
6	210.5	1.73
7	269.4	1.69
8	299.5	1.38
9	240.5	1.33
10	359.6	0.96

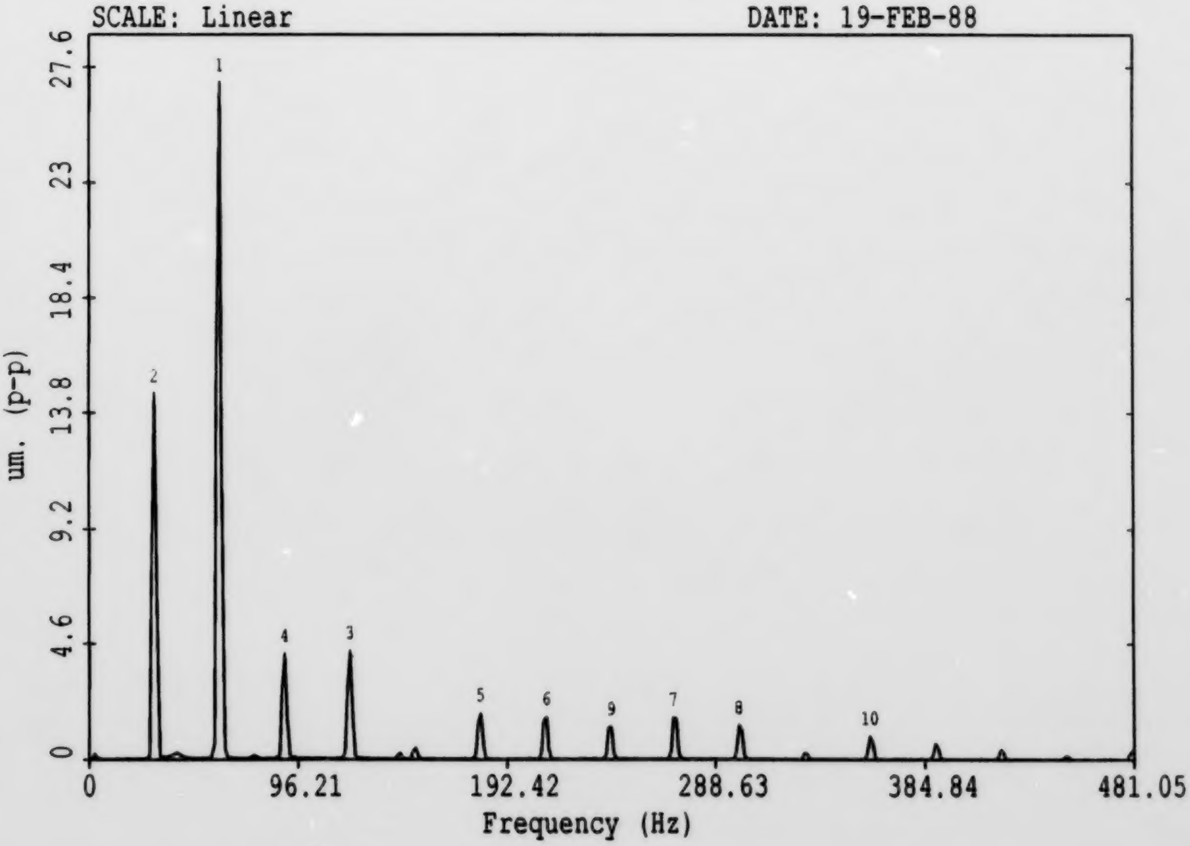


FIGURE B46

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG VERT.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	26.69
2	30.1	13.97
3	120.3	4.35
4	90.2	4.26
5	180.4	1.85
6	210.5	1.79
7	269.4	1.63
8	240.5	1.37
9	299.5	1.28
10	359.6	0.89

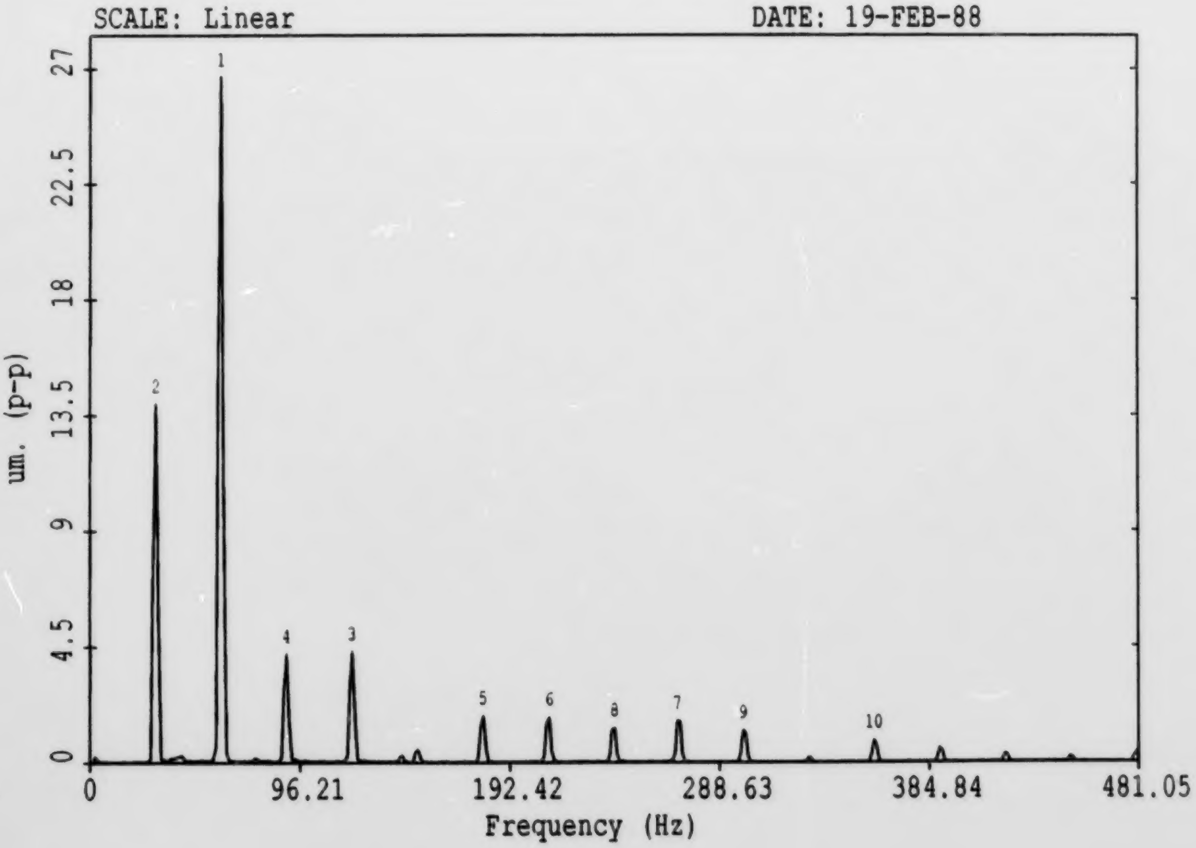


FIGURE B47

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG VERT.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	26.61
2	30.1	13.66
3	120.3	4.45
4	90.2	4.19
5	180.4	1.75
6	210.5	1.67
7	299.5	1.42
8	270.6	1.37
9	240.5	1.30
10	359.6	0.79

SCALE: Linear

DATE: 19-FEB-88

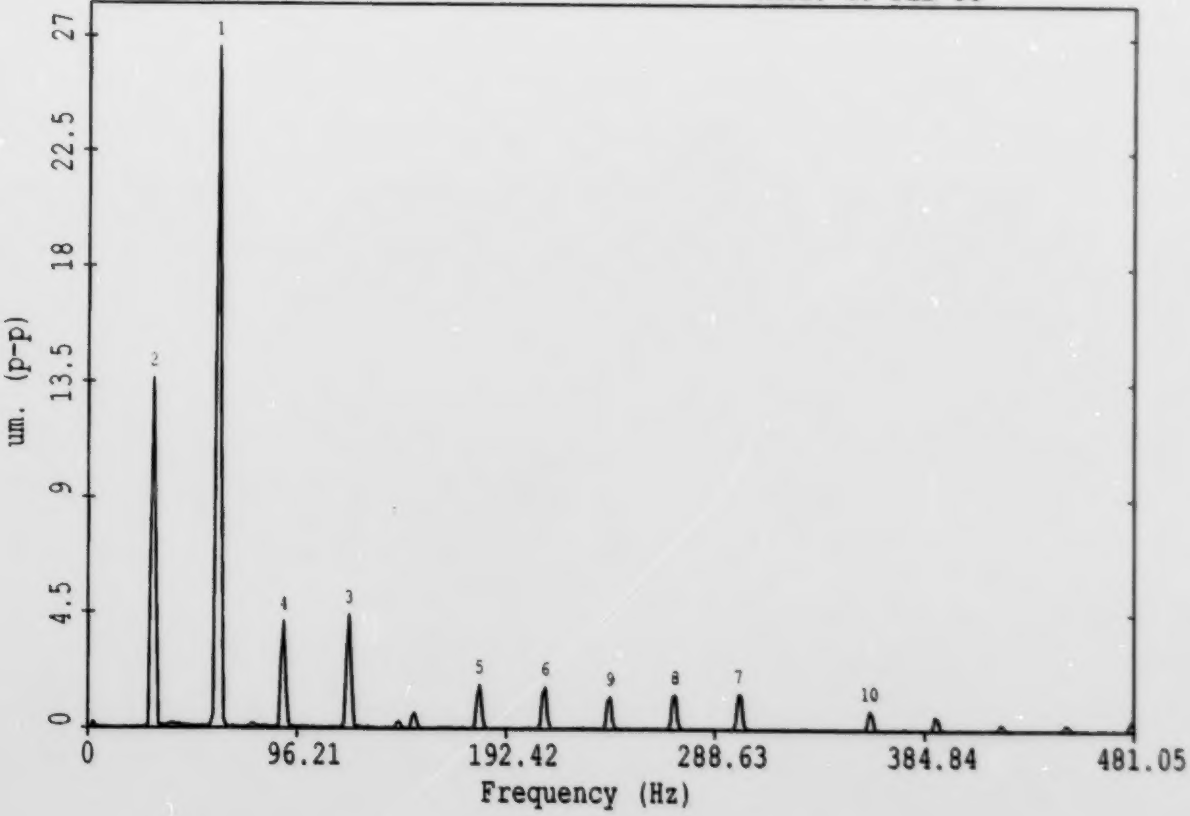


FIGURE B48

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL	:	AC GENERATOR SHAFT DISPL. OB BRG HOR.
PROCESS CONDITION	:	LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	25.00
2	30.1	23.19
3	120.3	4.54
4	90.2	3.22
5	180.4	2.09
6	300.7	1.87
7	270.6	1.76
8	240.5	1.53
9	210.5	1.45
10	360.8	1.05

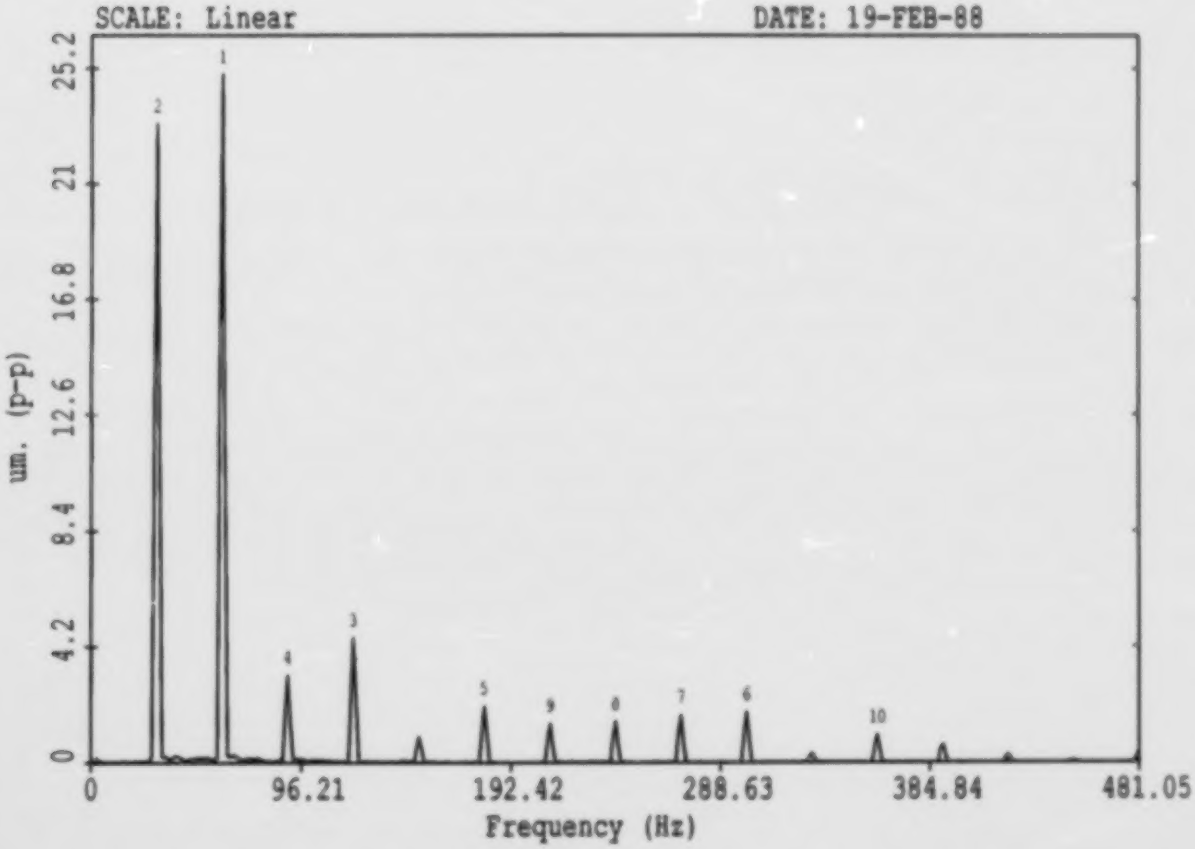


FIGURE B49

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG HOR.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	23.74
2	30.1	22.01
3	120.3	4.18
4	90.2	3.26
5	180.4	1.99
6	270.6	1.61
7	299.5	1.58
8	210.5	1.36
9	240.5	1.30
10	359.6	0.95

SCALE: Linear

DATE: 19-FEB-88

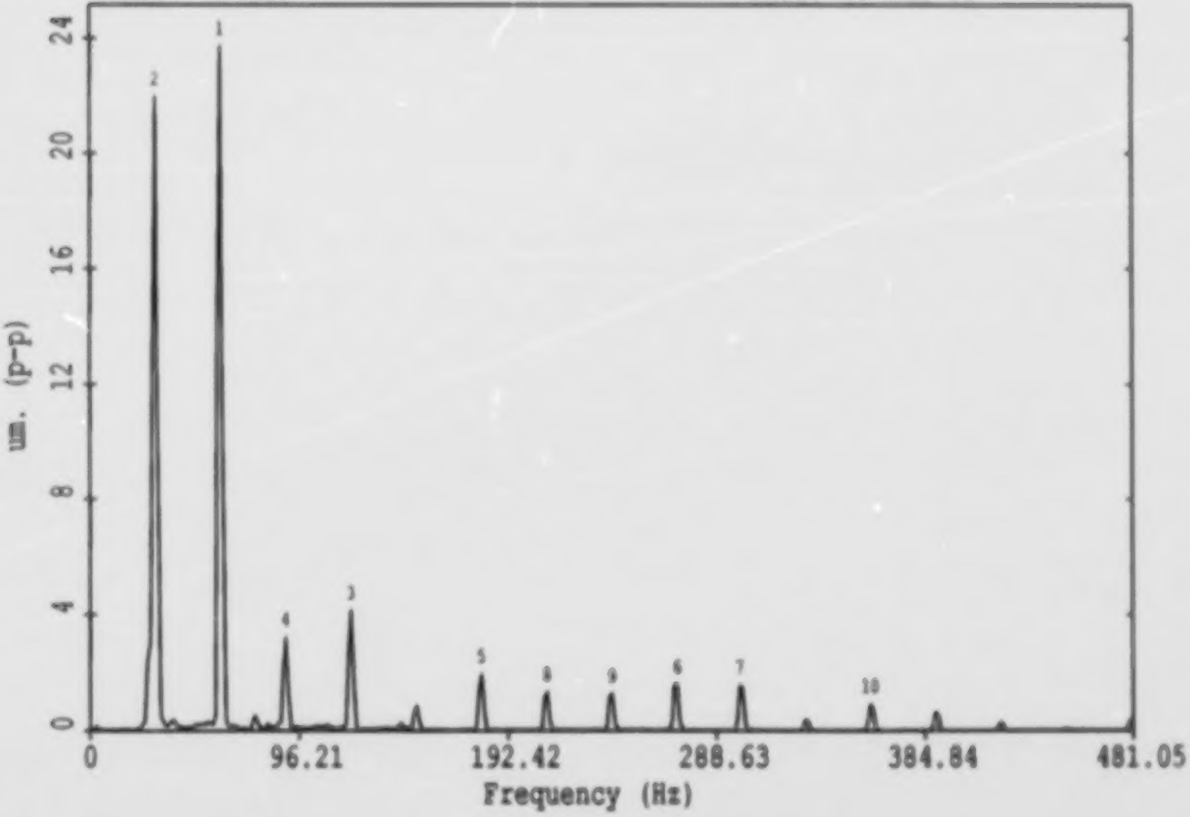


FIGURE B50

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	20.98
2	30.1	20.90
3	120.3	3.38
4	90.2	3.13
5	180.4	1.80
6	269.4	1.78
7	299.5	1.63
8	240.5	1.56
9	210.5	1.54
10	359.6	0.96

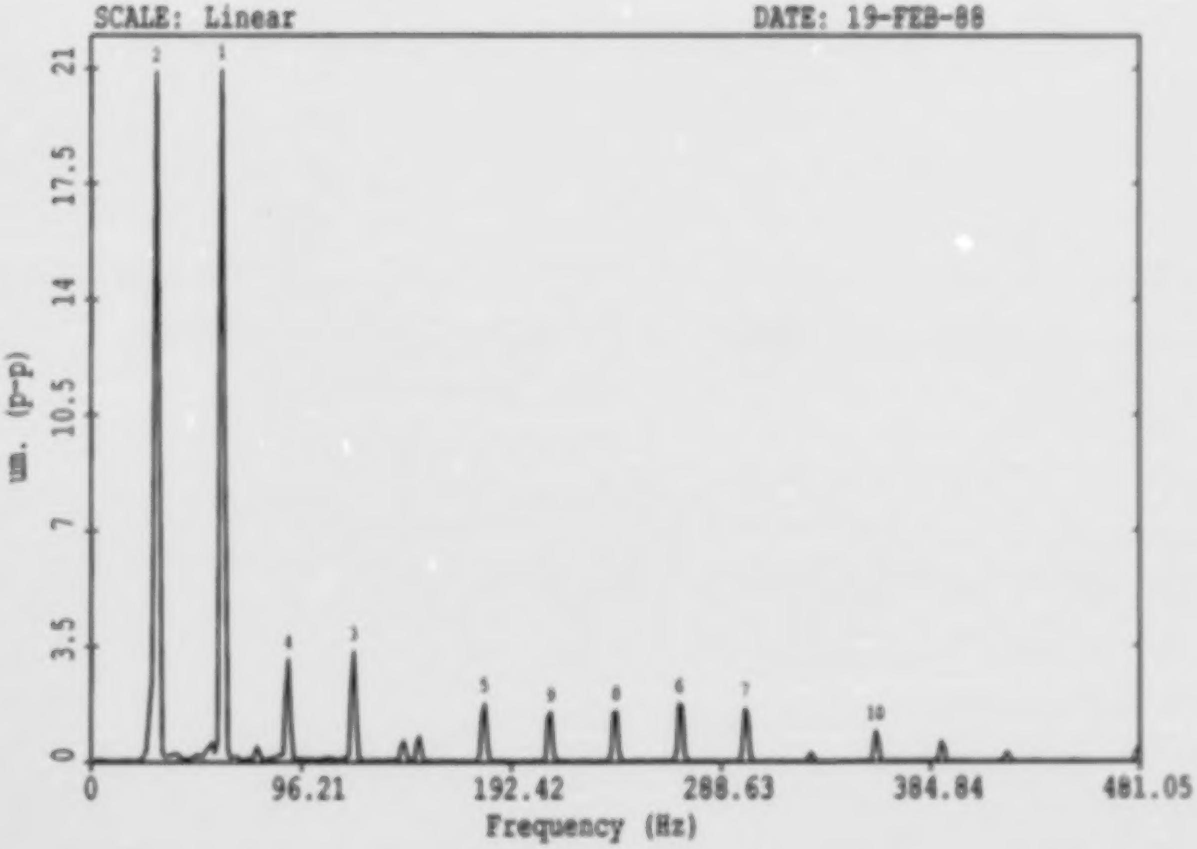


FIGURE B51

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG HOR.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	20.62
2	60.1	19.93
3	120.3	3.60
4	90.2	2.93
5	299.5	1.71
6	240.5	1.65
7	180.4	1.65
8	269.4	1.56
9	210.5	1.35
10	143.1	0.90

SCALE: Linear

DATE: 19-FEB-88

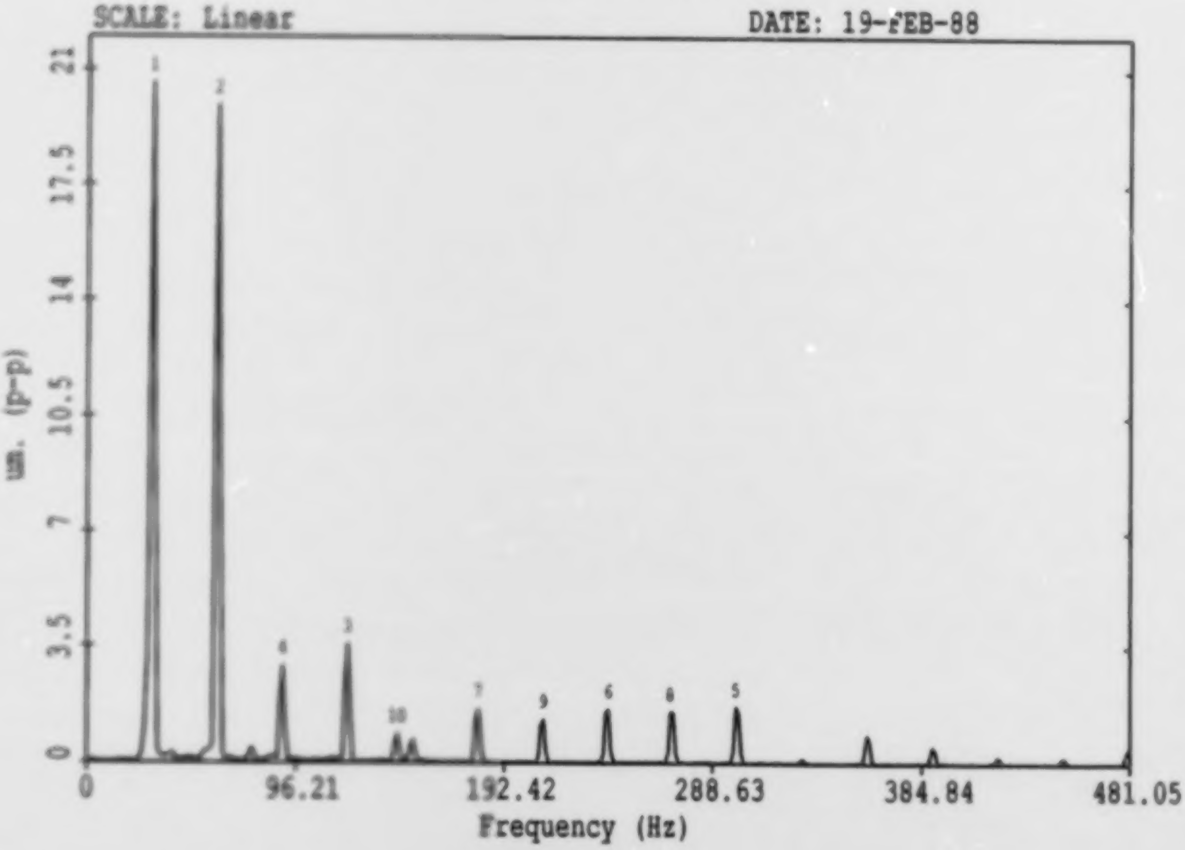


FIGURE B52

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG HOR.
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	24.49
2	30.1	20.29
3	120.3	4.31
4	90.2	2.91
5	180.4	1.86
6	300.7	1.60
7	240.5	1.52
8	270.6	1.43
9	143.1	1.42
10	210.5	1.16

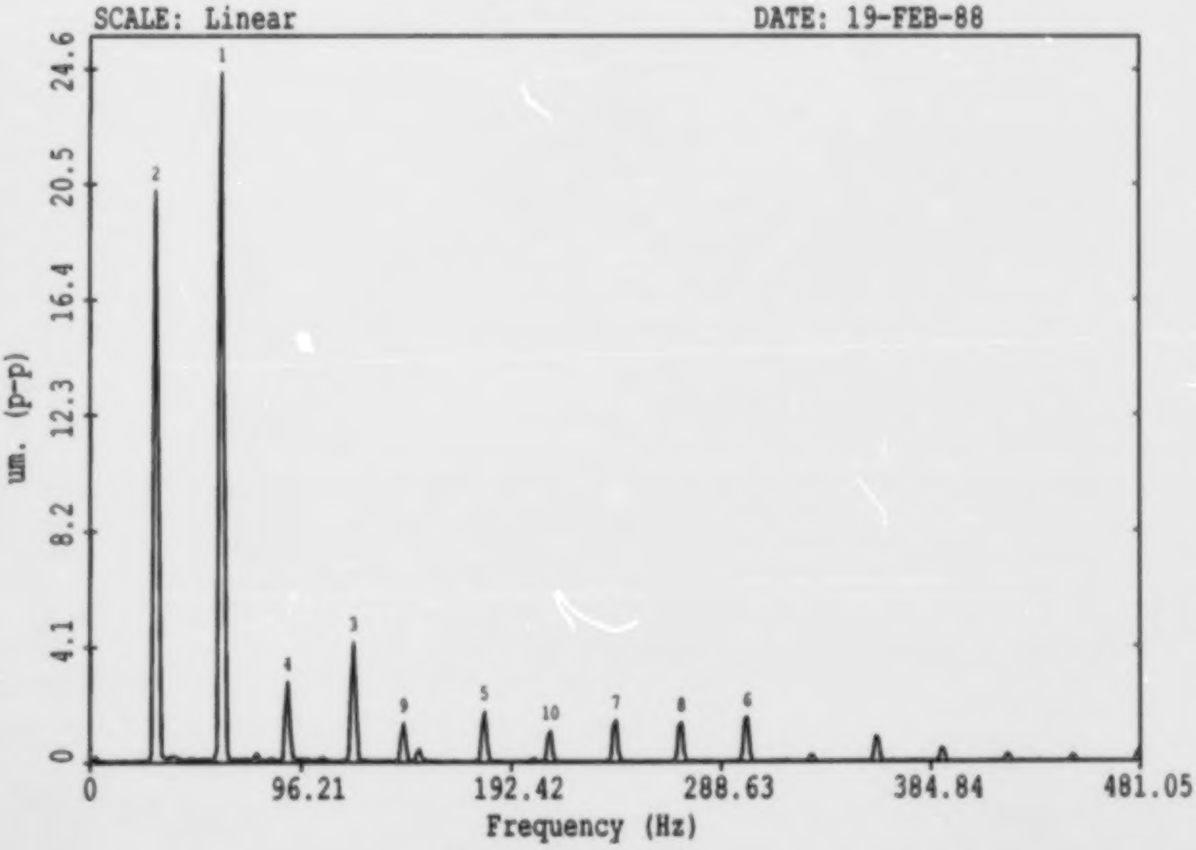


FIGURE B53

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	26.22
2	30.1	21.58
3	120.3	4.56
4	90.2	2.89
5	180.4	1.93
6	143.1	1.70
7	299.5	1.62
8	240.5	1.34
9	269.4	1.19
10	359.6	1.08

SCALE: Linear DATE: 19-FEB-88

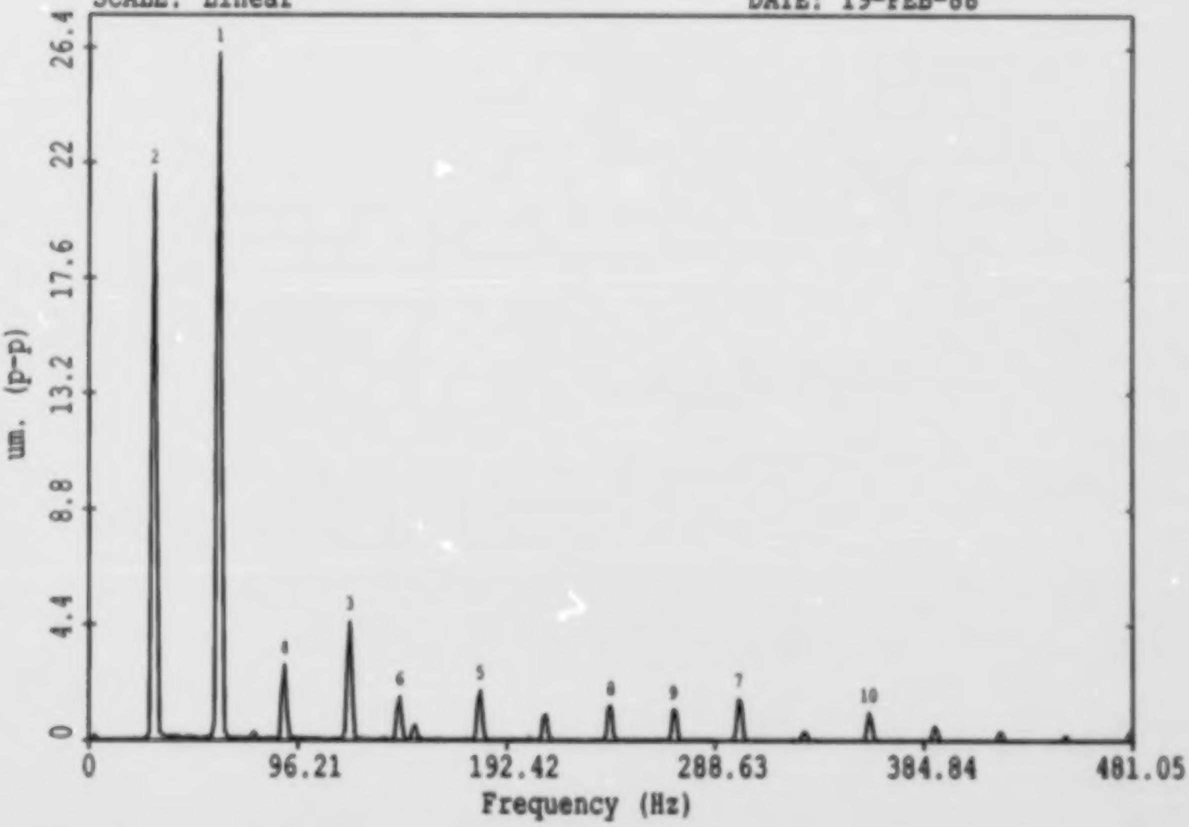


FIGURE B54

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	24.94
2	30.1	22.44
3	120.3	4.44
4	90.2	2.90
5	180.4	2.06
6	143.1	1.76
7	299.5	1.52
8	240.5	1.26
9	269.4	1.21
10	359.6	1.19

SCALE: Linear DATE: 19-FEB-88

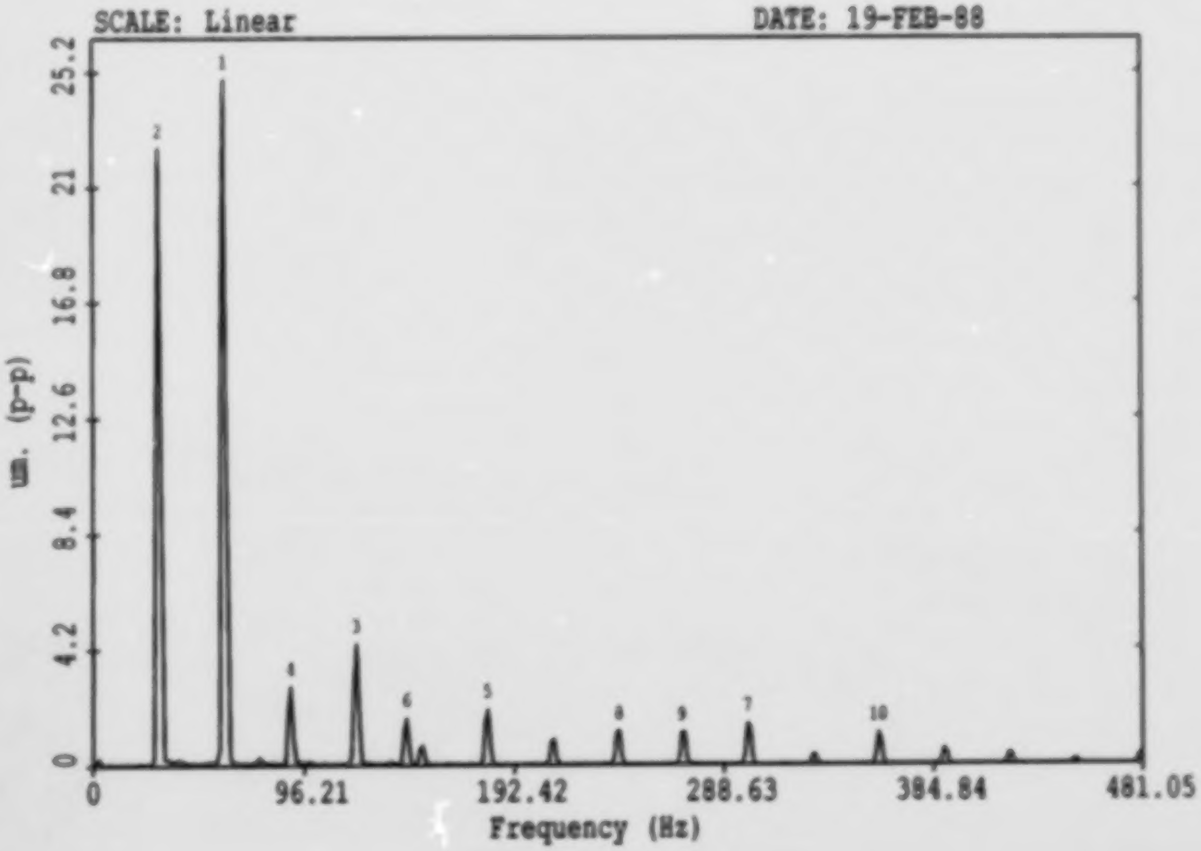


FIGURE B55

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. OB BRG HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	25.12
2	30.1	23.70
3	120.3	4.64
4	90.2	2.97
5	180.4	2.20
6	143.1	1.75
7	299.5	1.67
8	270.6	1.62
9	210.5	1.43
10	240.5	1.26

SCALE: Linear DATE: 19-FEB-88

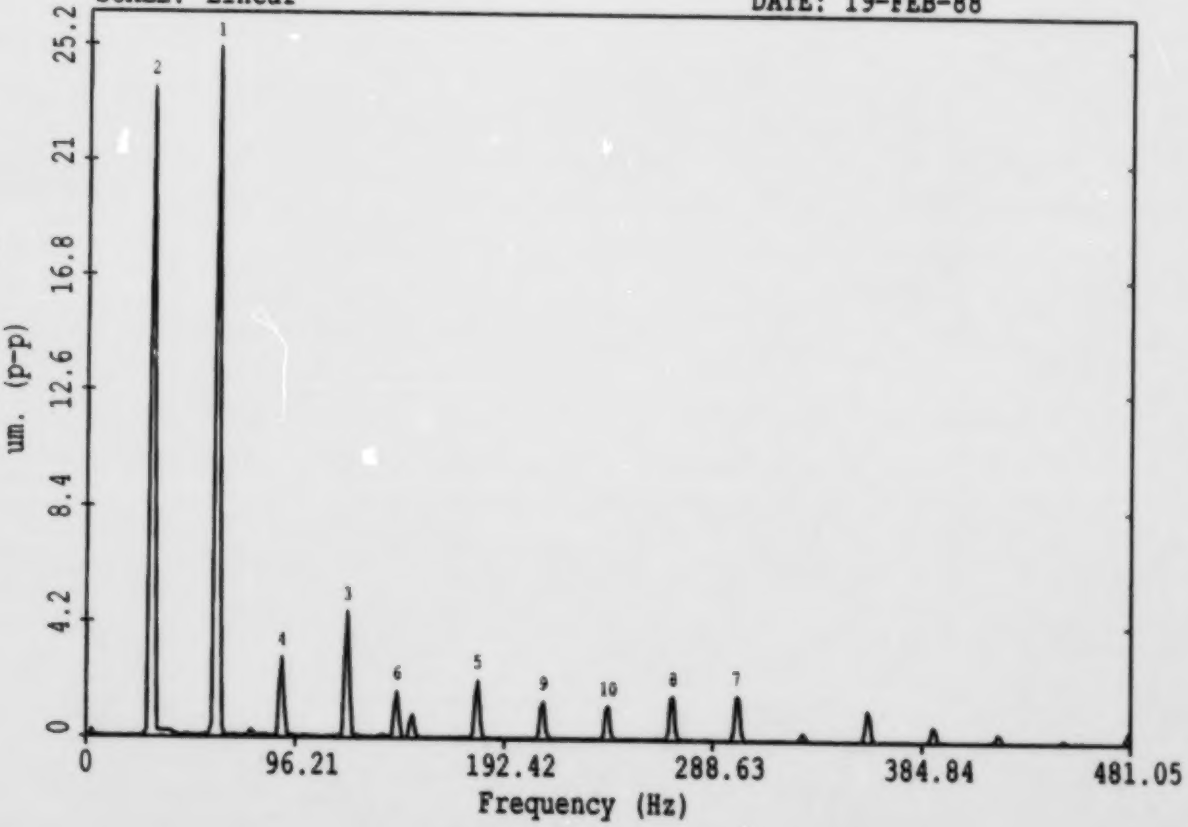


FIGURE B56

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG VERT.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	9.01
2	30.1	5.84
3	120.3	2.16
4	90.2	1.77
5	180.4	1.27
6	143.1	1.04
7	330.7	0.70
8	420.9	0.64
9	300.7	0.59
10	210.5	0.58

SCALE: Linear

DATE: 19-FEB-88

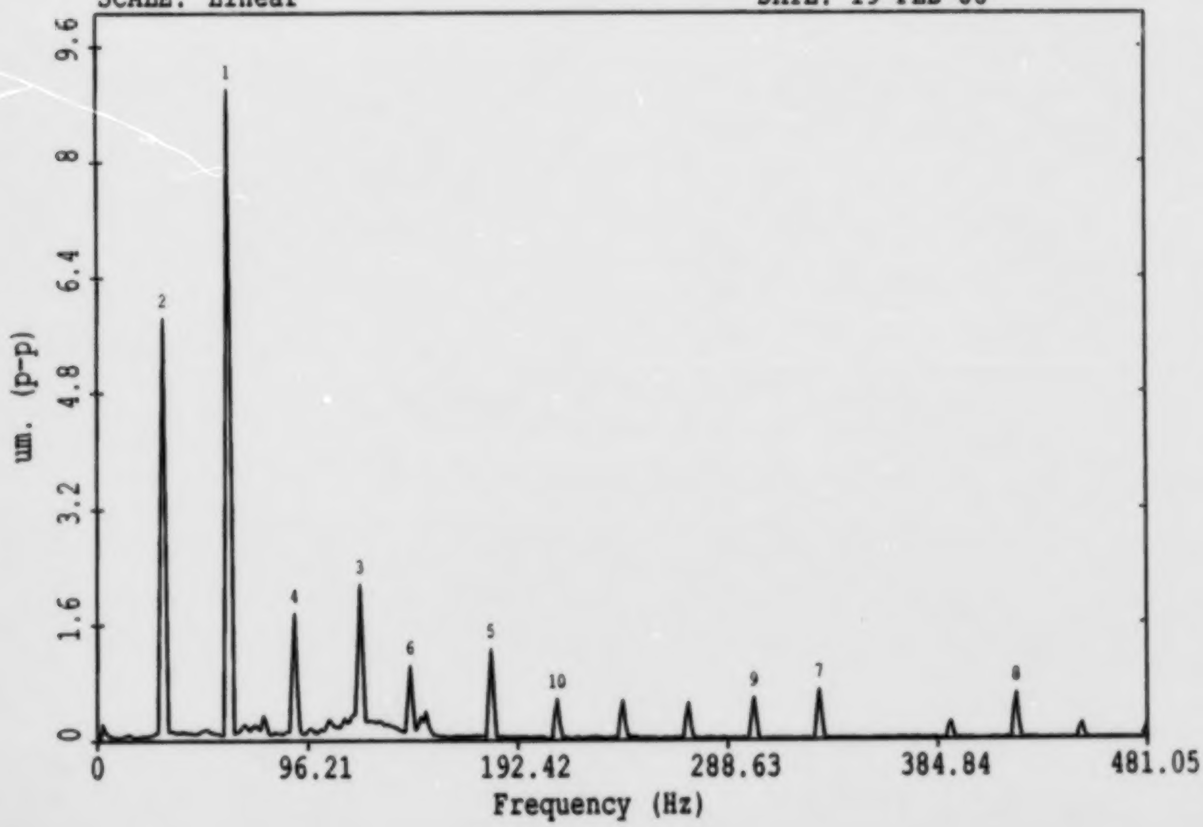


FIGURE B57

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG VERT.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	8.40
2	30.1	5.70
3	120.3	3.21
4	90.2	1.89
5	180.4	1.36
6	87.8	1.25
7	143.1	1.01
8	81.8	0.85
9	329.5	0.64
10	210.5	0.57

SCALE: Linear

DATE: 19-FEB-88

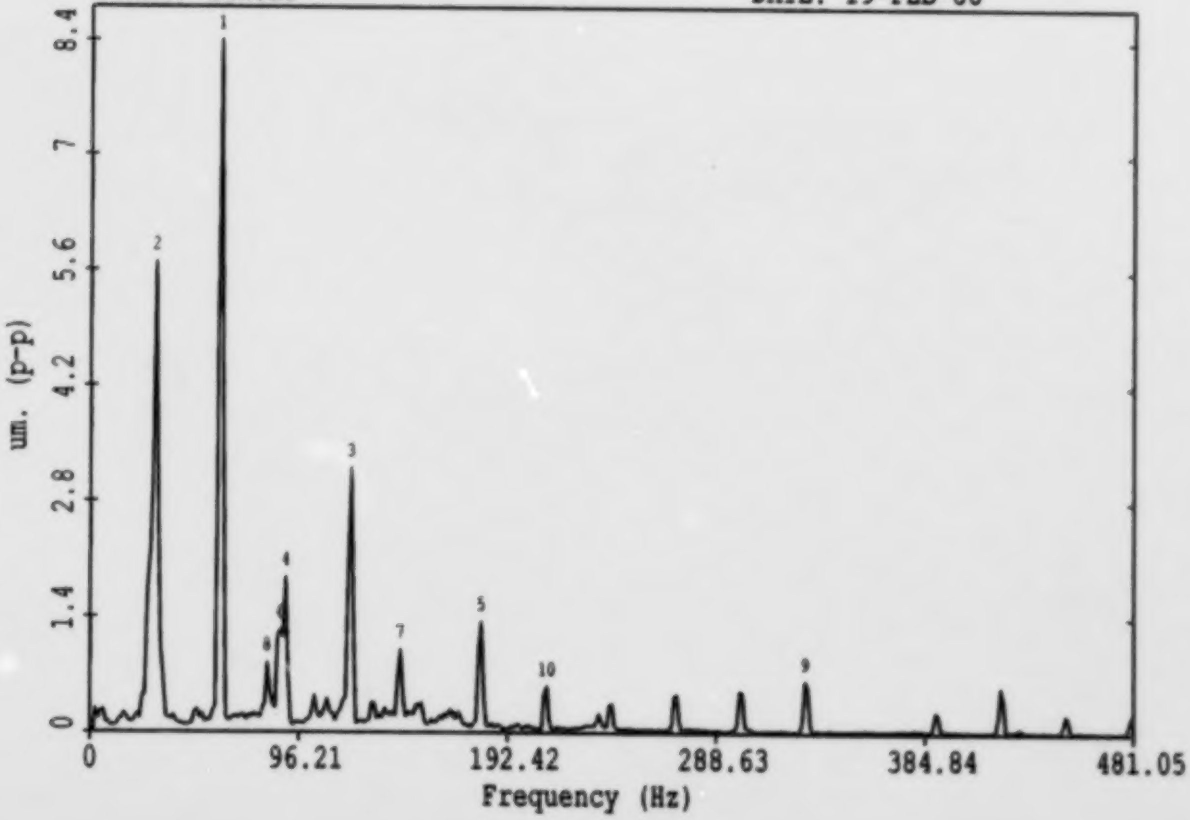


FIGURE B58

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	6.70
2	30.1	6.07
3	120.3	3.86
4	90.2	1.96
5	180.4	1.47
6	143.1	1.41
7	83.0	0.89
8	150.3	0.86
9	329.5	0.68
10	419.7	0.55

SCALE: Linear DATE: 19-FEB-88

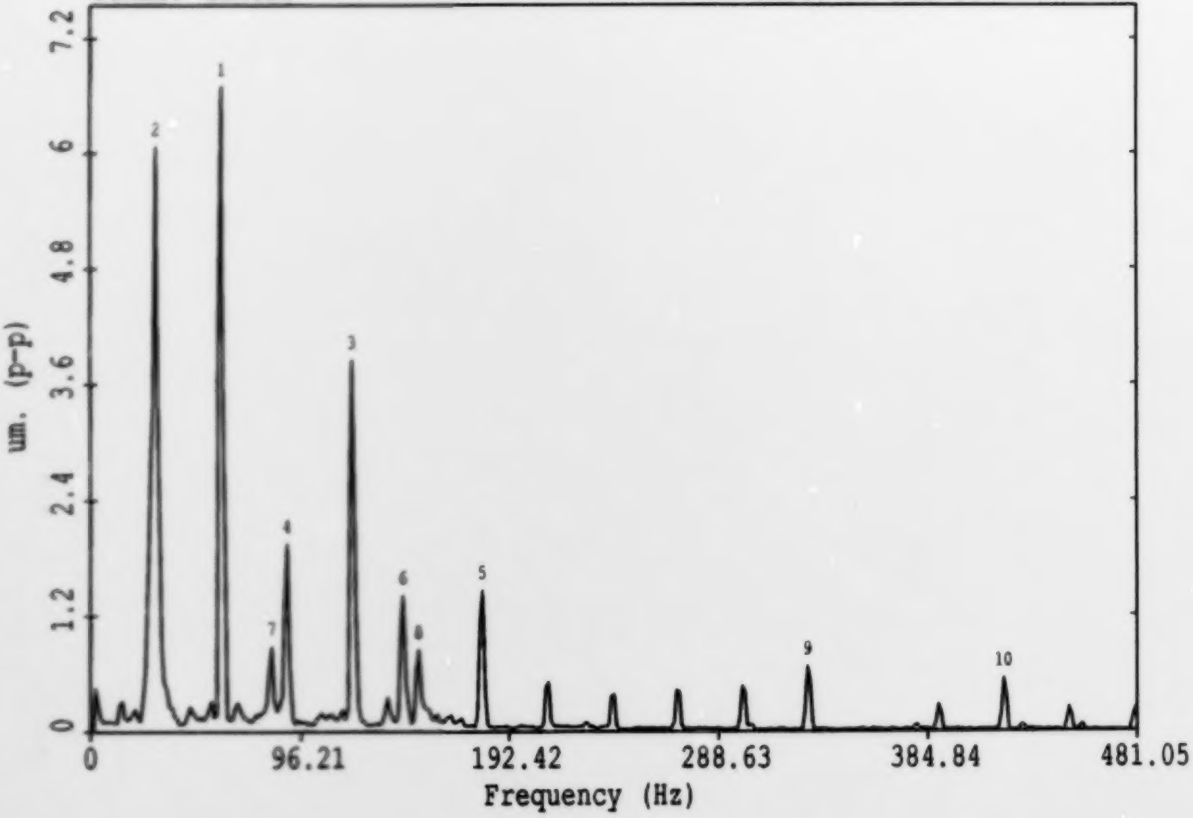


FIGURE B59

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG VERT.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	7.52
2	60.1	5.99
3	120.3	3.28
4	90.2	1.87
5	143.1	1.82
6	180.4	1.56
7	150.3	0.94
8	329.5	0.68
9	83.0	0.63
10	419.7	0.59

SCALE: Linear

DATE: 19-FEB-88

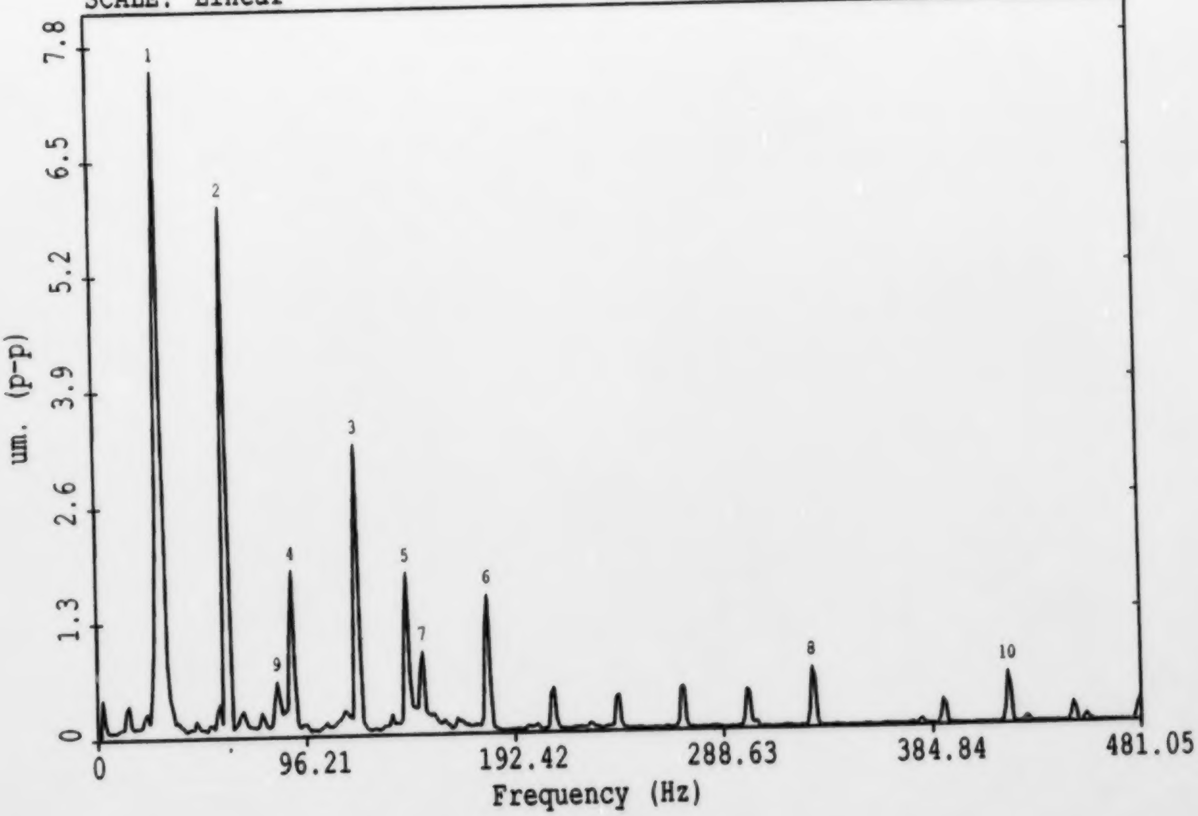


FIGURE B60

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG VERT.
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	7.53
2	120.3	3.14
3	60.1	1.98
4	143.1	1.95
5	90.2	1.64
6	180.4	1.60
7	329.5	0.68
8	419.7	0.67
9	270.6	0.52
10	240.5	0.48

SCALE: Linear

DATE: 19-FEB-88

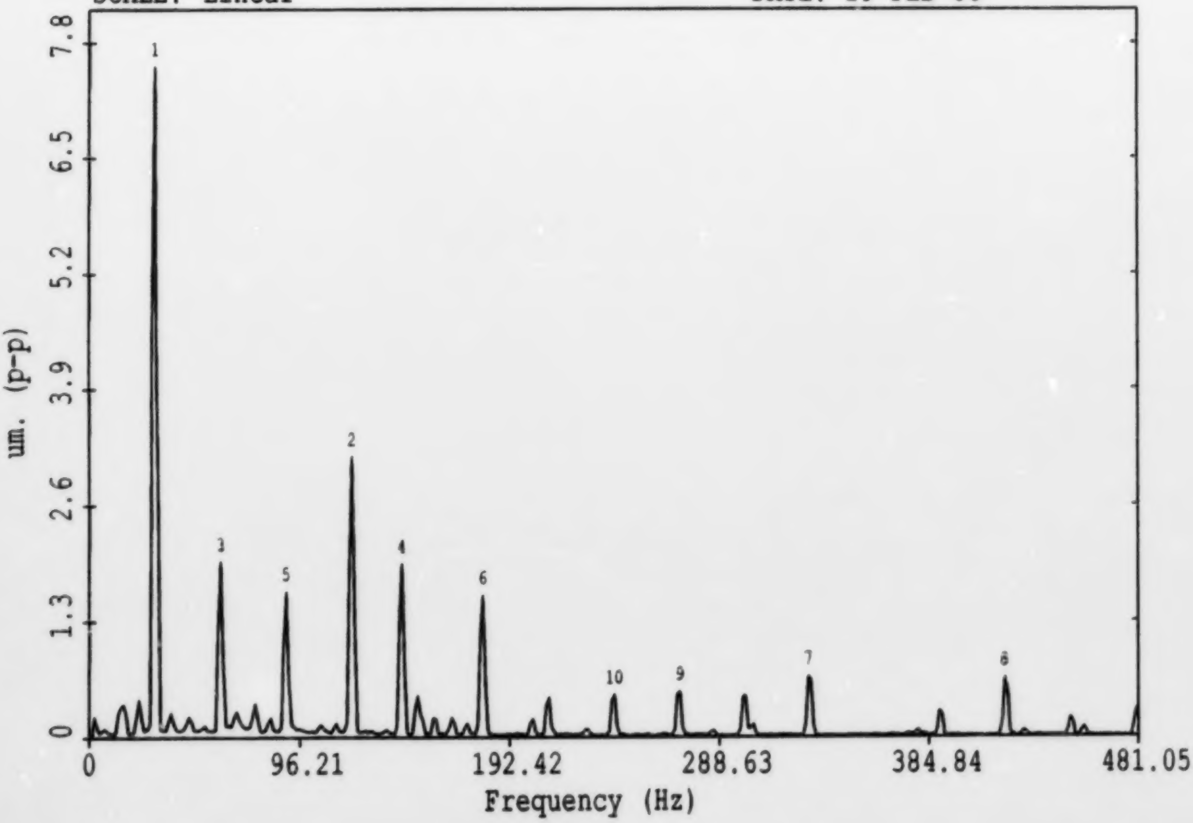


FIGURE B61

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG VERT.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	7.72
2	30.1	7.69
3	120.3	2.07
4	143.1	1.61
5	90.2	1.31
6	180.4	1.24
7	329.5	0.77
8	419.7	0.71
9	269.4	0.52
10	240.5	0.51

SCALE: Linear

DATE: 19-FEB-88

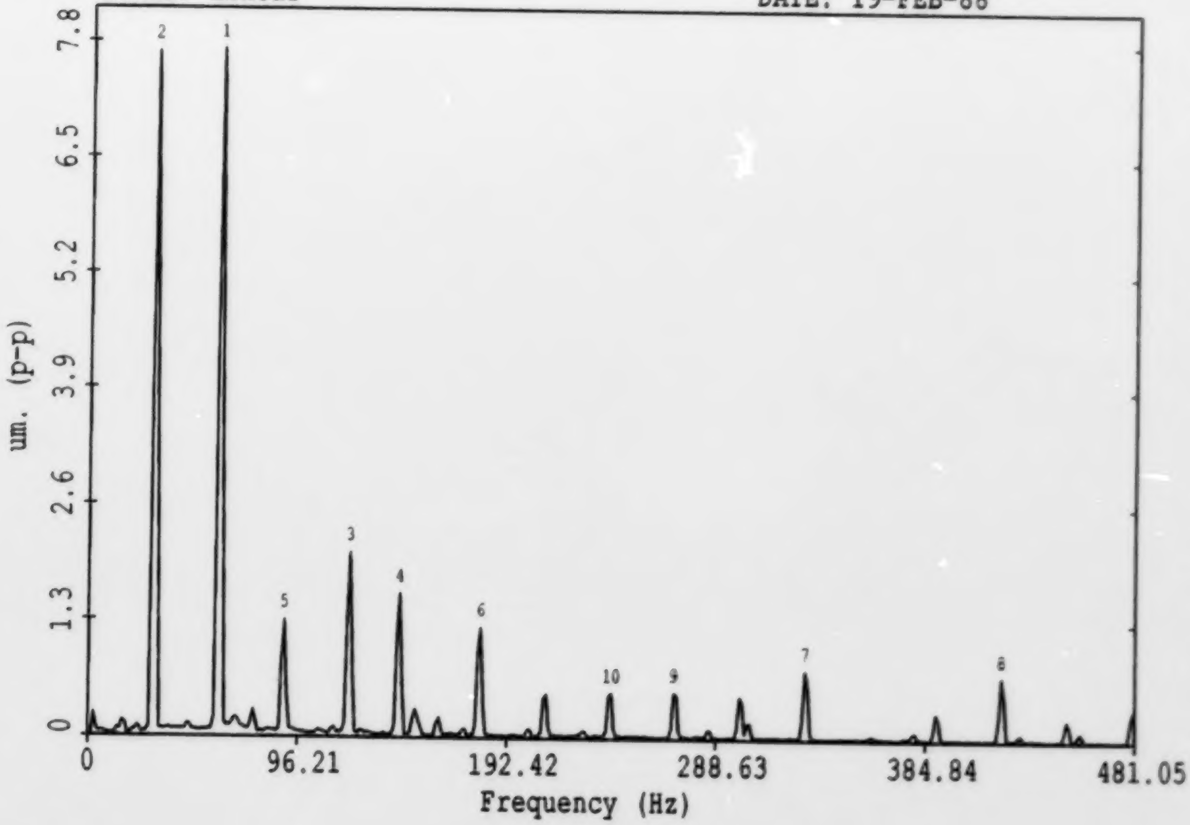


FIGURE B62

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG VERT.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	8.58
2	30.1	8.33
3	120.3	2.13
4	143.1	1.54
5	90.2	1.32
6	180.4	1.12
7	329.5	0.78
8	419.7	0.73
9	210.5	0.58
10	240.5	0.58

SCALE: Linear

DATE: 19-FEB-88

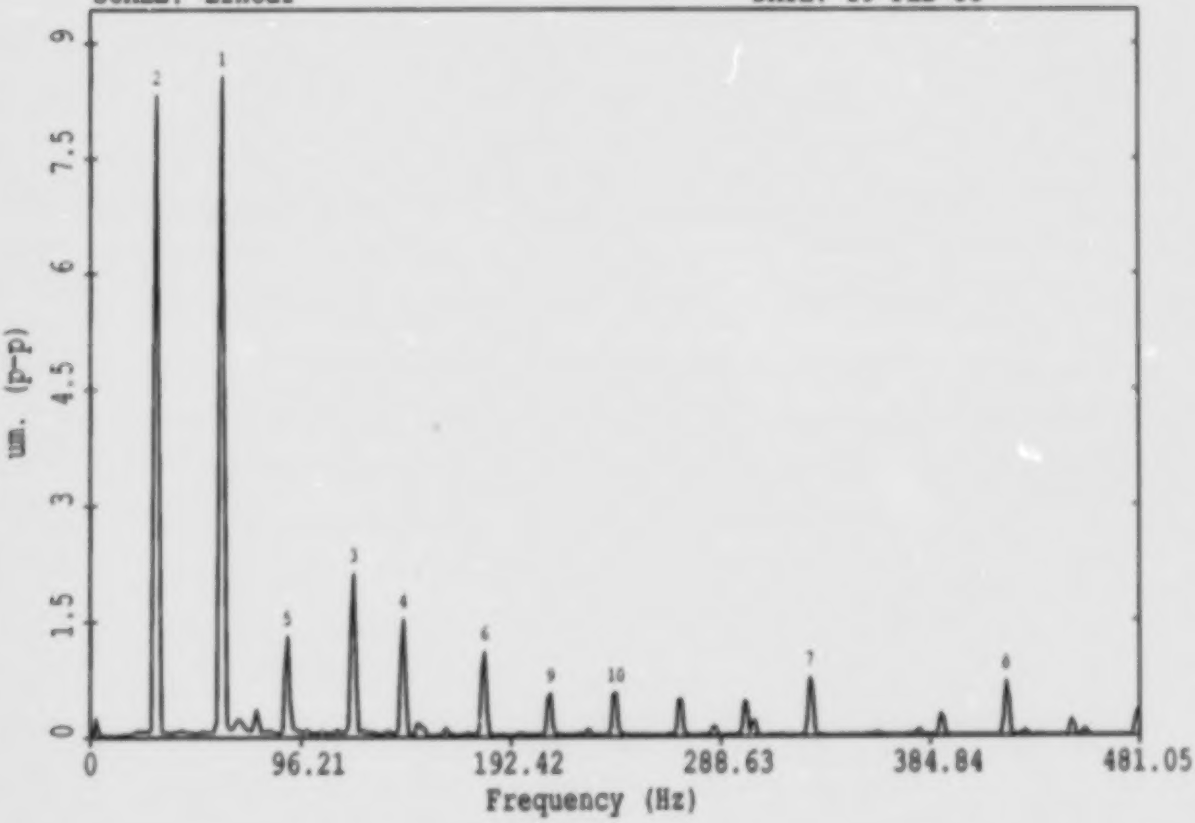


FIGURE B63

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG VERT.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	9.23
2	60.1	8.65
3	120.3	2.10
4	143.1	1.44
5	90.2	1.31
6	180.4	1.11
7	329.5	0.80
8	419.7	0.72
9	240.5	0.66
10	75.8	0.64

SCALE: Linear

DATE: 19-FEB-88

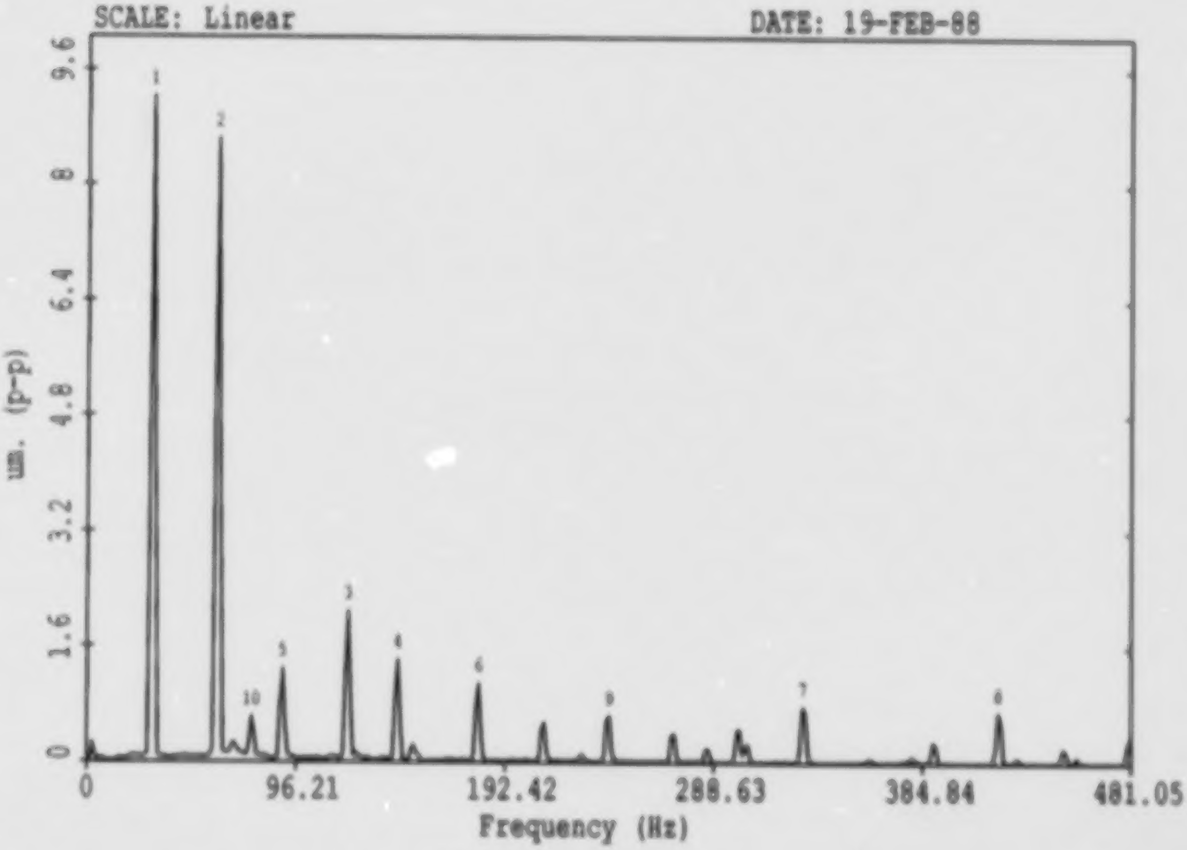


FIGURE B64

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG HOR.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	11.11
2	30.1	9.39
3	90.2	2.50
4	120.3	1.70
5	180.4	1.12
6	150.3	0.81
7	420.9	0.75
8	330.7	0.66
9	300.7	0.62
10	143.1	0.57

SCALE: Linear DATE: 19-FEB-88

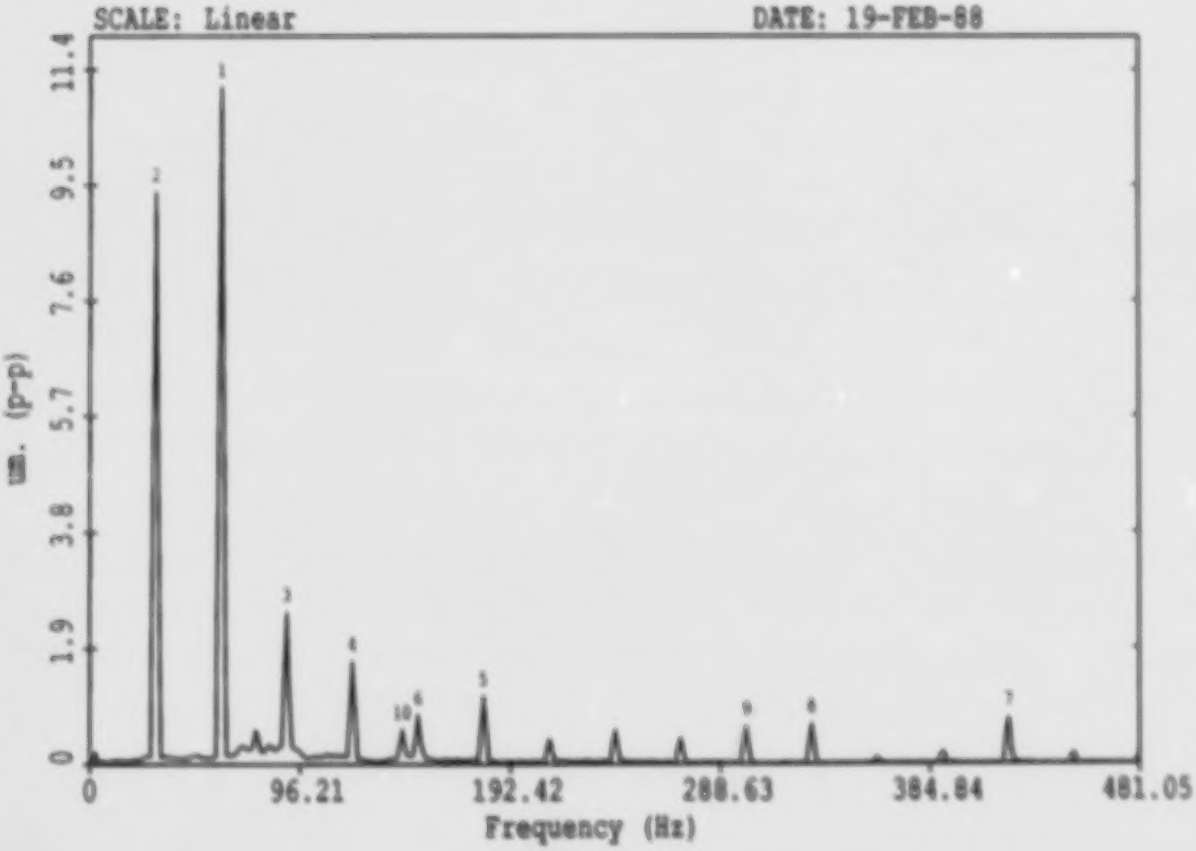


FIGURE B65

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG HOR.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	13.54
2	30.1	9.69
3	27.7	6.05
4	81.8	2.36
5	90.2	1.93
6	120.3	1.38
7	87.8	1.34
8	180.4	1.27
9	75.8	1.17
10	54.1	0.98

SCALE: Linear DATE: 19-FEB-88

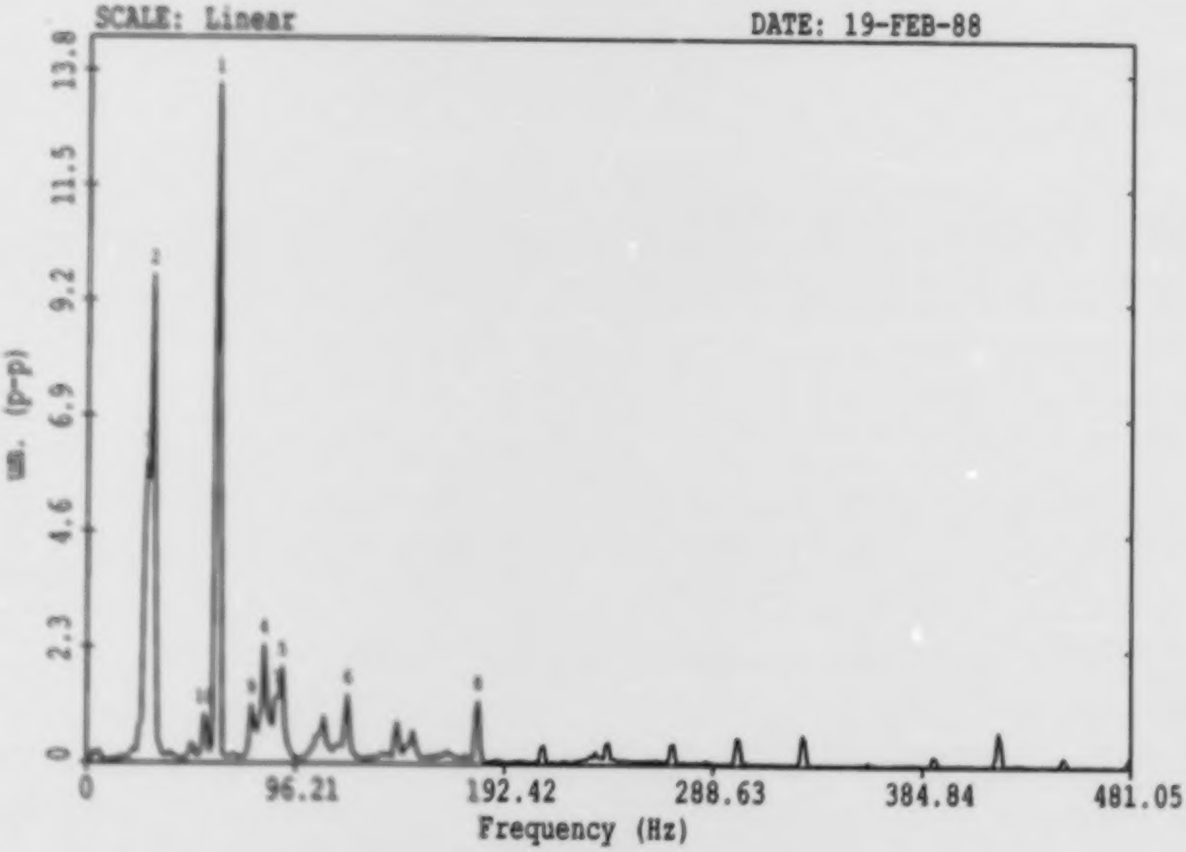


FIGURE B66

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	19.06
2	30.1	12.47
3	90.2	2.15
4	143.1	1.98
5	83.0	1.92
6	120.3	1.44
7	75.8	1.35
8	180.4	1.10
9	150.3	1.04
10	85.4	0.99

SCALE: Linear

DATE: 19-FEB-88

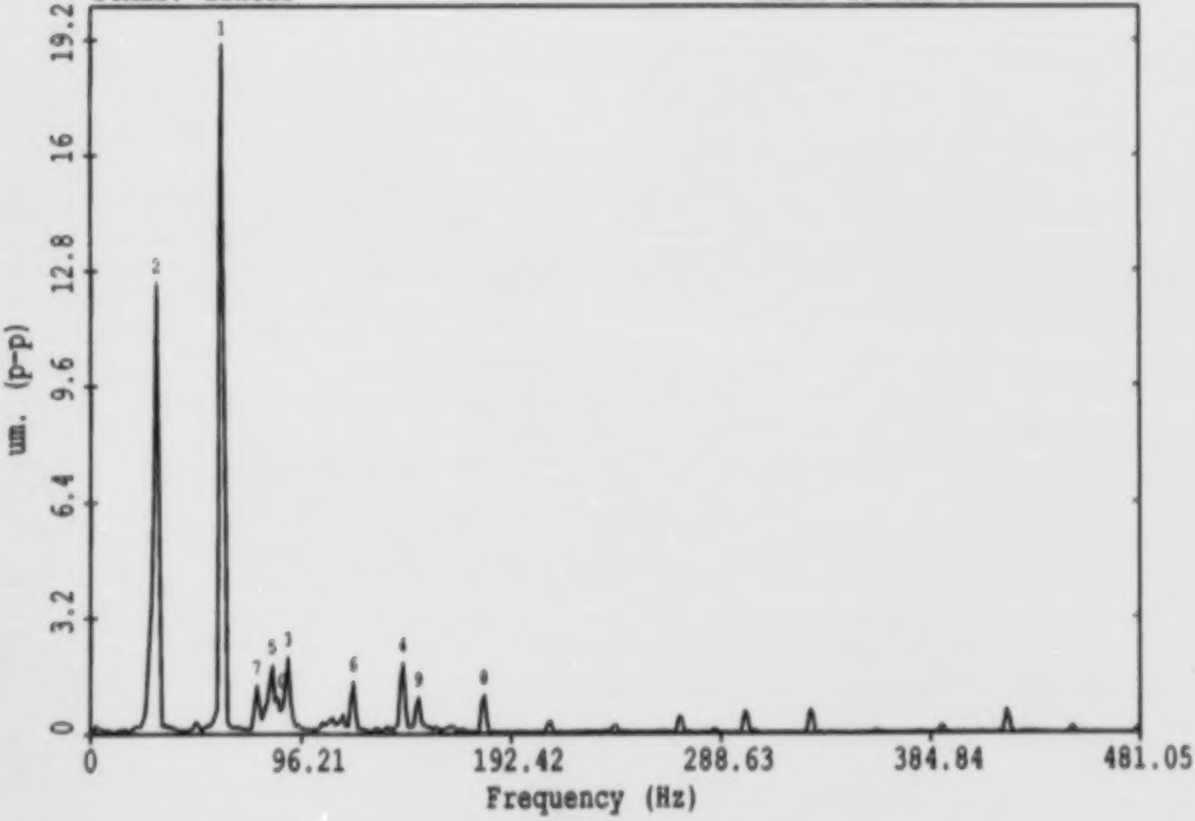


FIGURE B67

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG HOR.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	22.00
2	30.1	13.44
3	143.1	2.39
4	90.2	2.01
5	84.2	1.97
6	120.3	1.33
7	75.8	1.25
8	180.4	1.18
9	150.3	1.06
10	329.5	0.69

SCALE: Linear DATE: 19-FEB-88

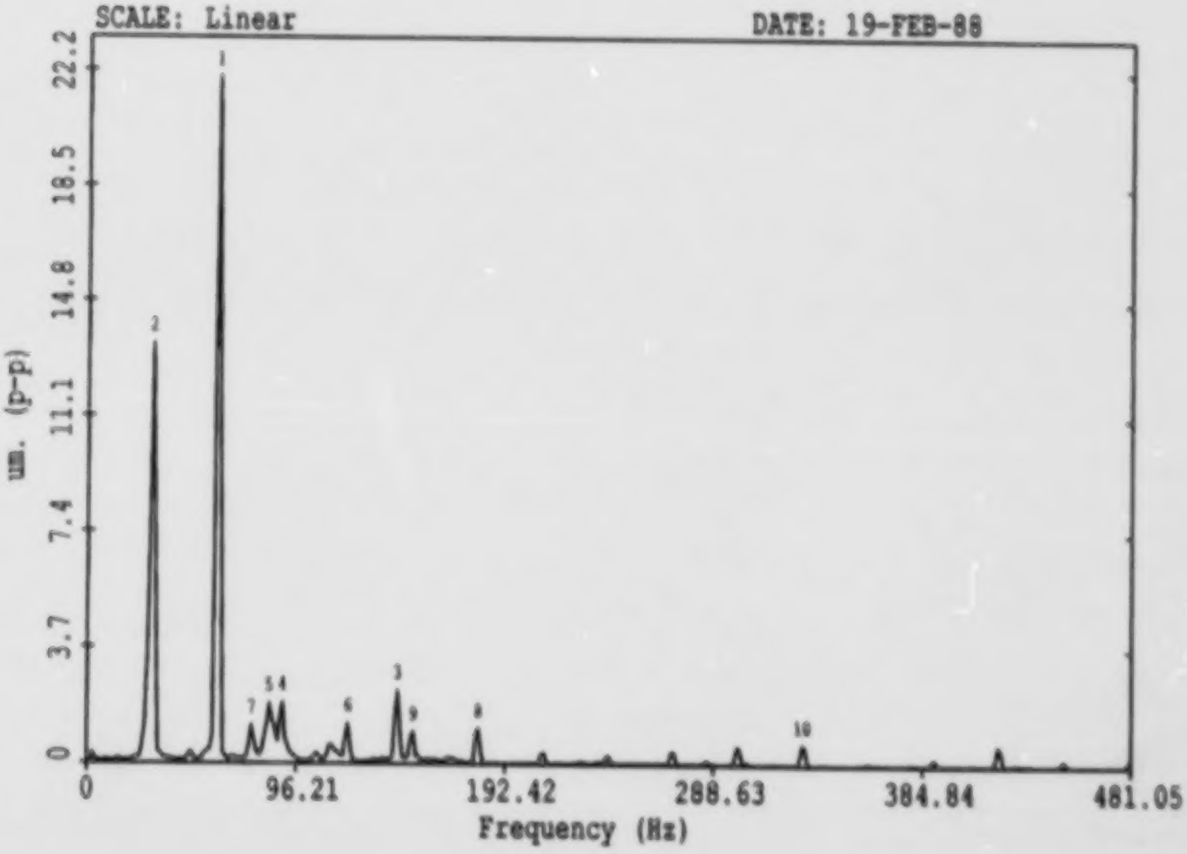


FIGURE B68

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG HOR.
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	18.86
2	30.1	14.93
3	143.1	3.05
4	180.4	1.51
5	90.2	1.46
6	75.8	1.46
7	120.3	1.26
8	83.0	1.09
9	419.7	0.73
10	329.5	0.70

SCALE: Linear

DATE: 19-FEB-88

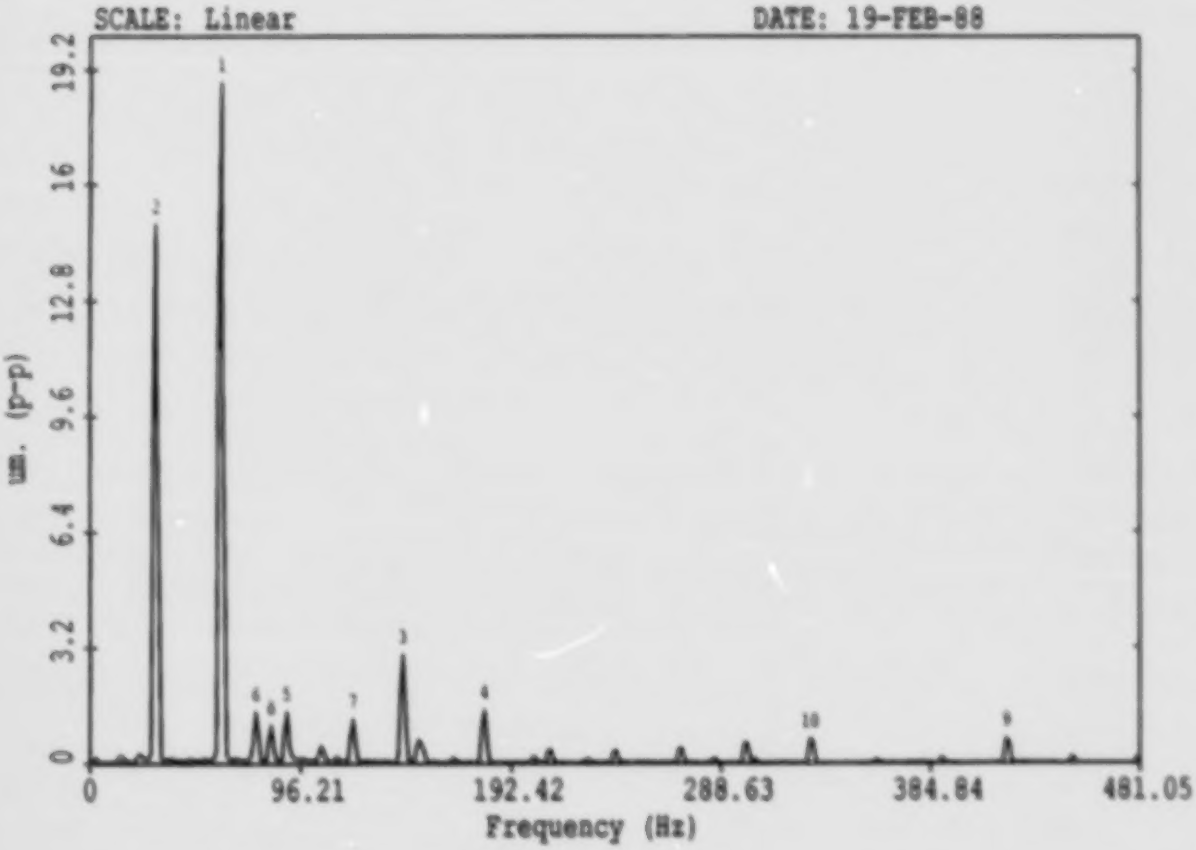


FIGURE B69

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	13.82
2	60.1	8.46
3	143.1	3.07
4	120.3	2.04
5	90.2	1.76
6	75.8	1.26
7	180.4	1.16
8	419.7	0.84
9	329.5	0.71
10	299.5	0.60

SCALE: Linear

DATE: 19-FEB-88

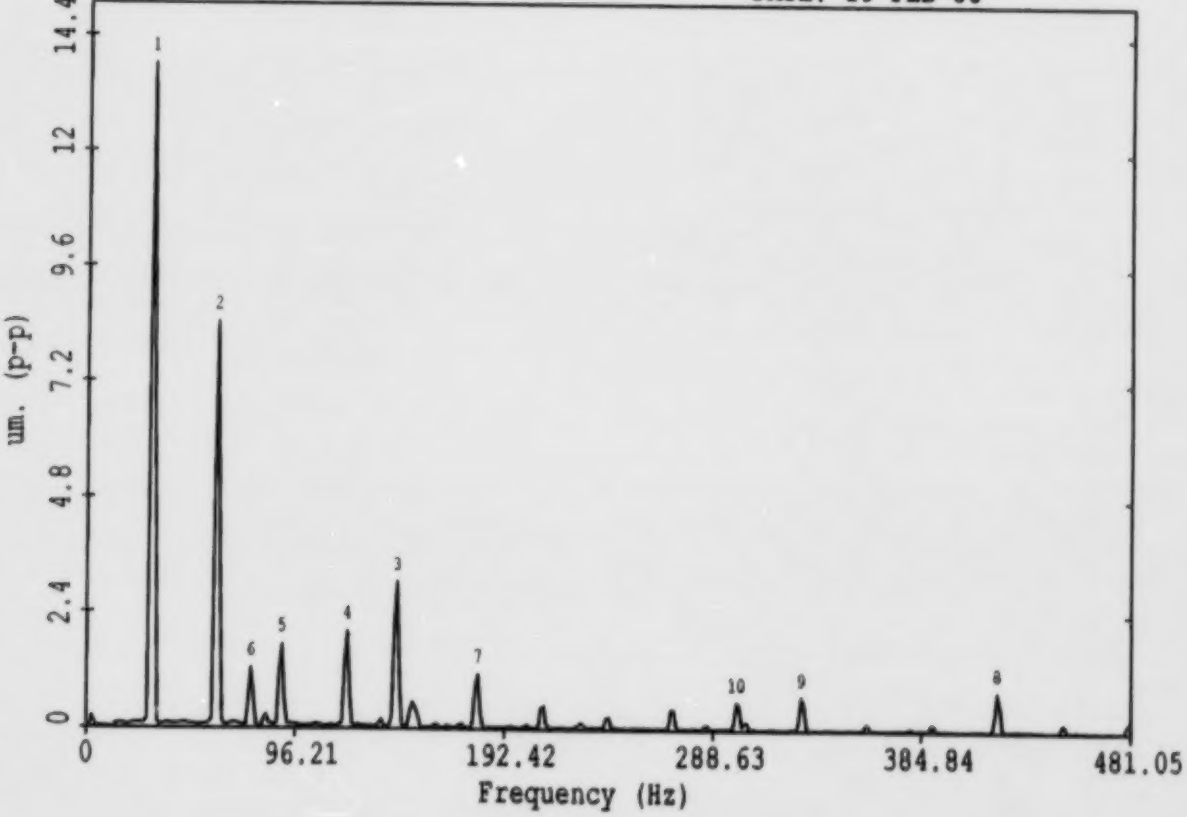


FIGURE B70

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	13.68
2	60.1	11.40
3	143.1	2.96
4	90.2	1.69
5	120.3	1.57
6	180.4	1.43
7	75.8	1.23
8	419.7	0.84
9	329.5	0.70
10	299.5	0.57

SCALE: Linear DATE: 19-FEB-88

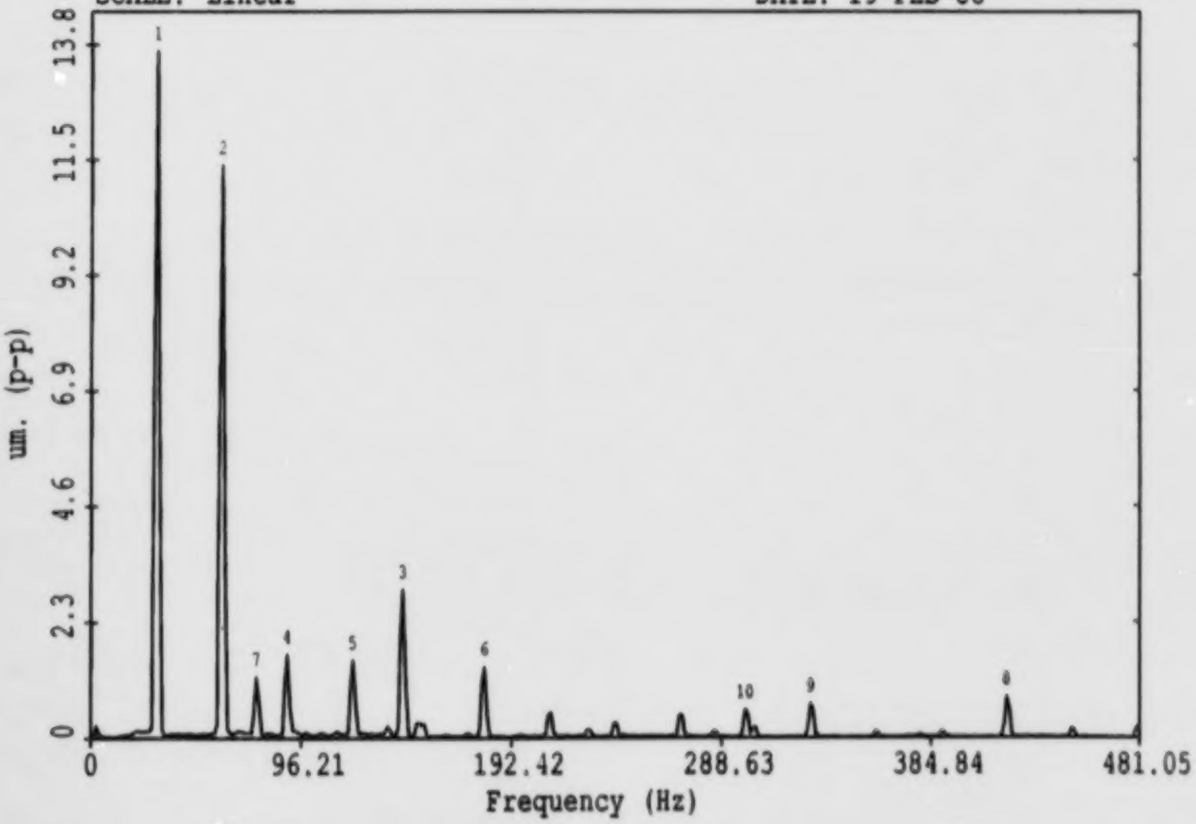


FIGURE B71

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : AC GENERATOR SHAFT DISPL. IB BRG HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	13.85
2	60.1	11.24
3	143.1	2.86
4	90.2	1.78
5	120.3	1.75
6	180.4	1.52
7	75.8	1.33
8	419.7	0.83
9	329.5	0.64
10	299.5	0.57

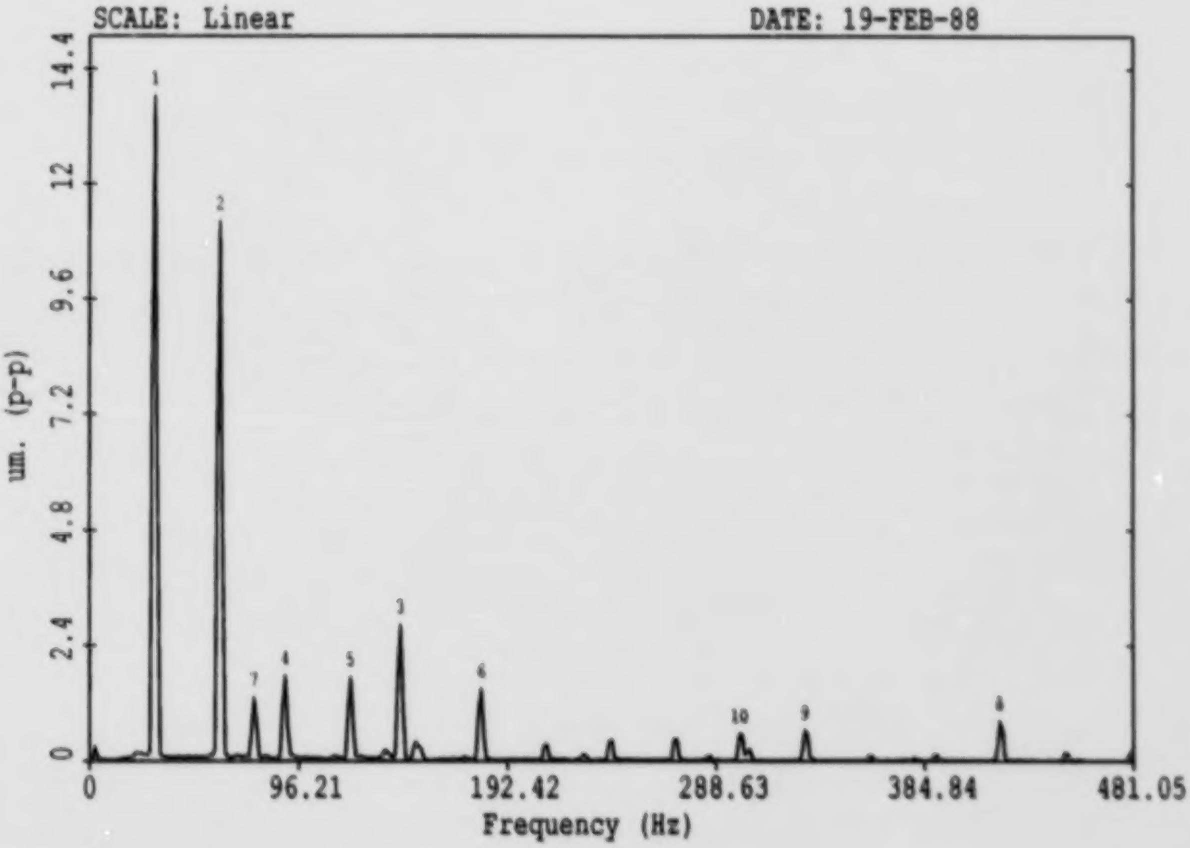

SCALE: Linear
DATE: 19-FEB-88

FIGURE B72

APPENDIX C

REDUCTION GEARBOX VELOCITY SPECTRA

TABLE C1
DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2 - REDUCTION GEARBOX
FIGURE NUMBERS OF VELOCITY SPECTRA

Measurement		FFT Spectrum Figure No.							
		Load (MW)							
		0	1	1.5	2	3	4	5	6.8
Reduction Gearbox Casing Velocity	Vertical Direction	C1	C2	C3	C4	C5	C6	C7	C8
	Horizontal Direction	C9	C10	C11	C12	C13	C14	C15	C16
	Axial Direction	C17	C18	C19	C20	C21	C22	C23	C24

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.68
2	120.3	0.47
3	60.1	0.37
4	90.2	0.25
5	180.4	0.24
6	147.9	0.24
7	286.2	0.17
8	151.5	0.15
9	97.4	0.12
10	113.0	0.12

SCALE: Linear DATE: 19-FEB-88

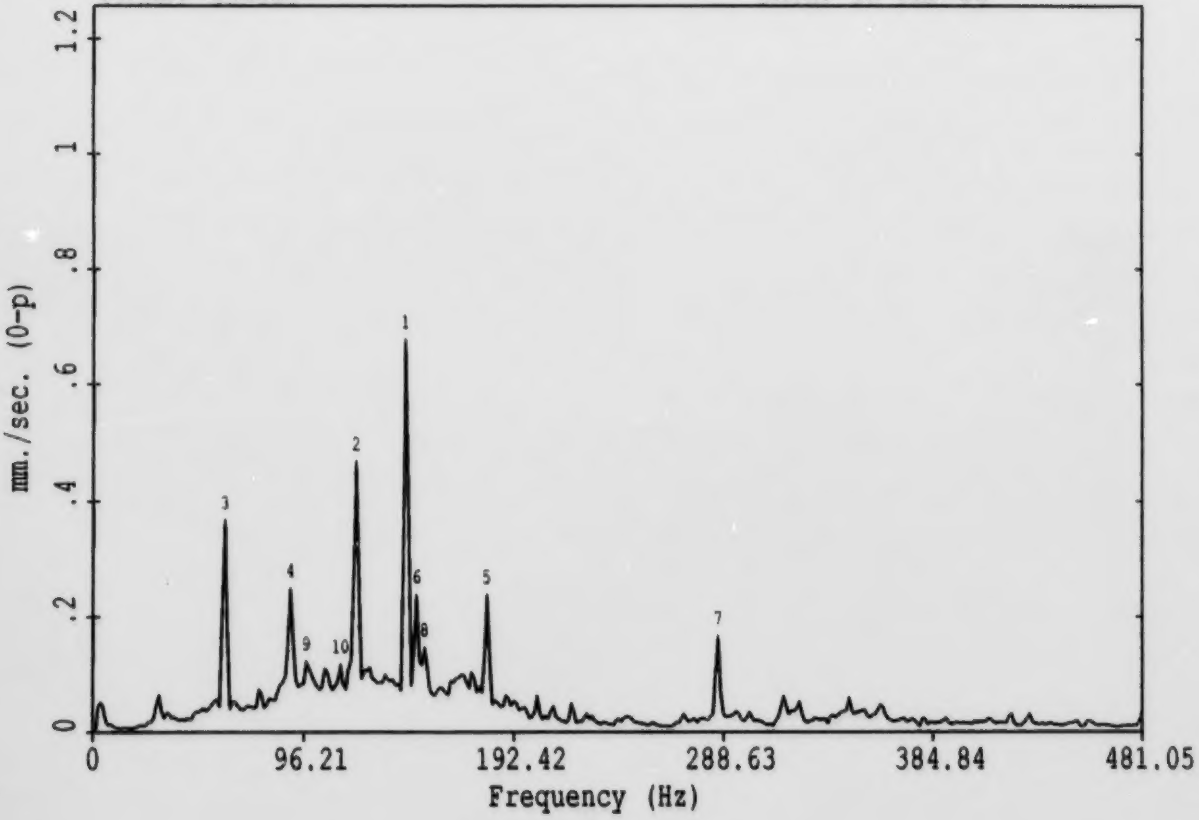


FIGURE C1

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	54.1	0.48
2	81.8	0.47
3	109.4	0.46
4	27.7	0.44
5	143.1	0.44
6	57.7	0.35
7	103.4	0.32
8	111.8	0.29
9	84.2	0.28
10	90.2	0.22

SCALE: Linear

DATE: 19-FEB-88

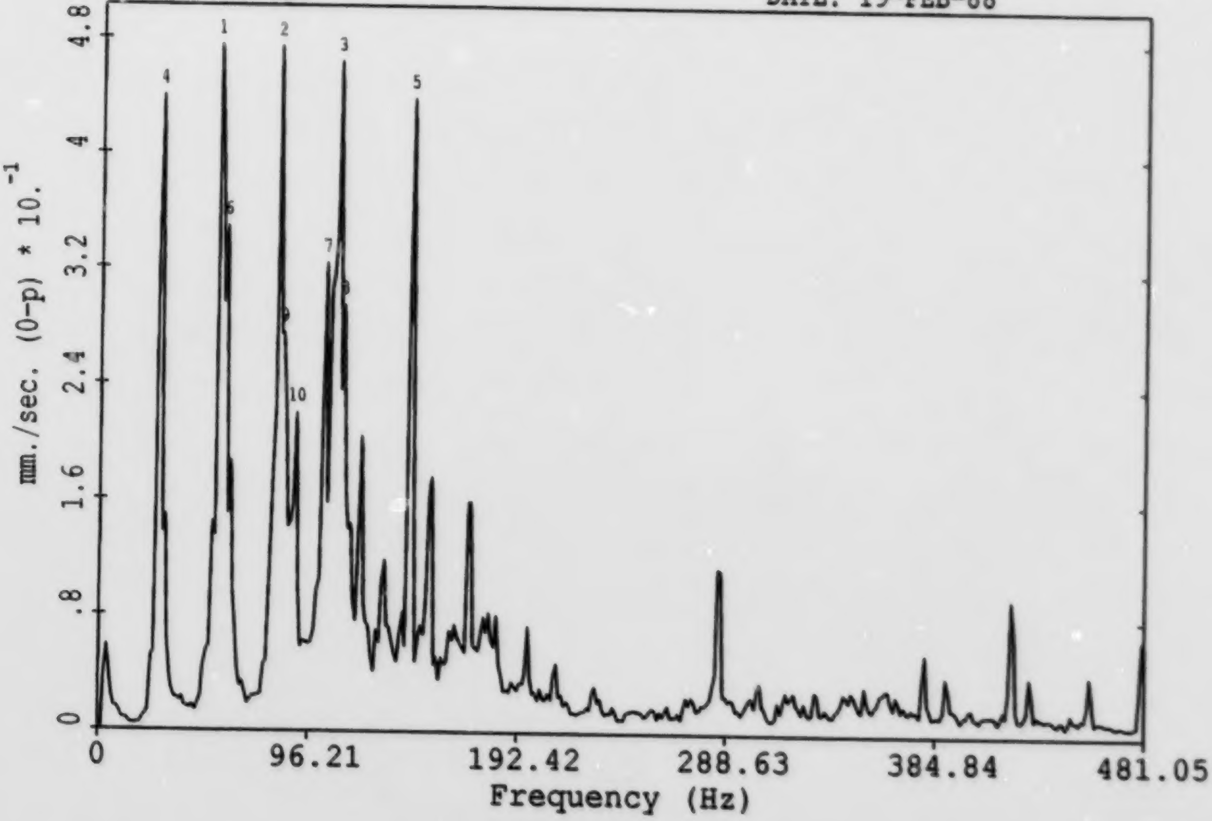


FIGURE C2

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.63
2	55.3	0.59
3	60.1	0.43
4	27.7	0.33
5	57.7	0.31
6	120.3	0.20
7	90.2	0.19
8	153.9	0.16
9	103.4	0.15
10	115.5	0.14

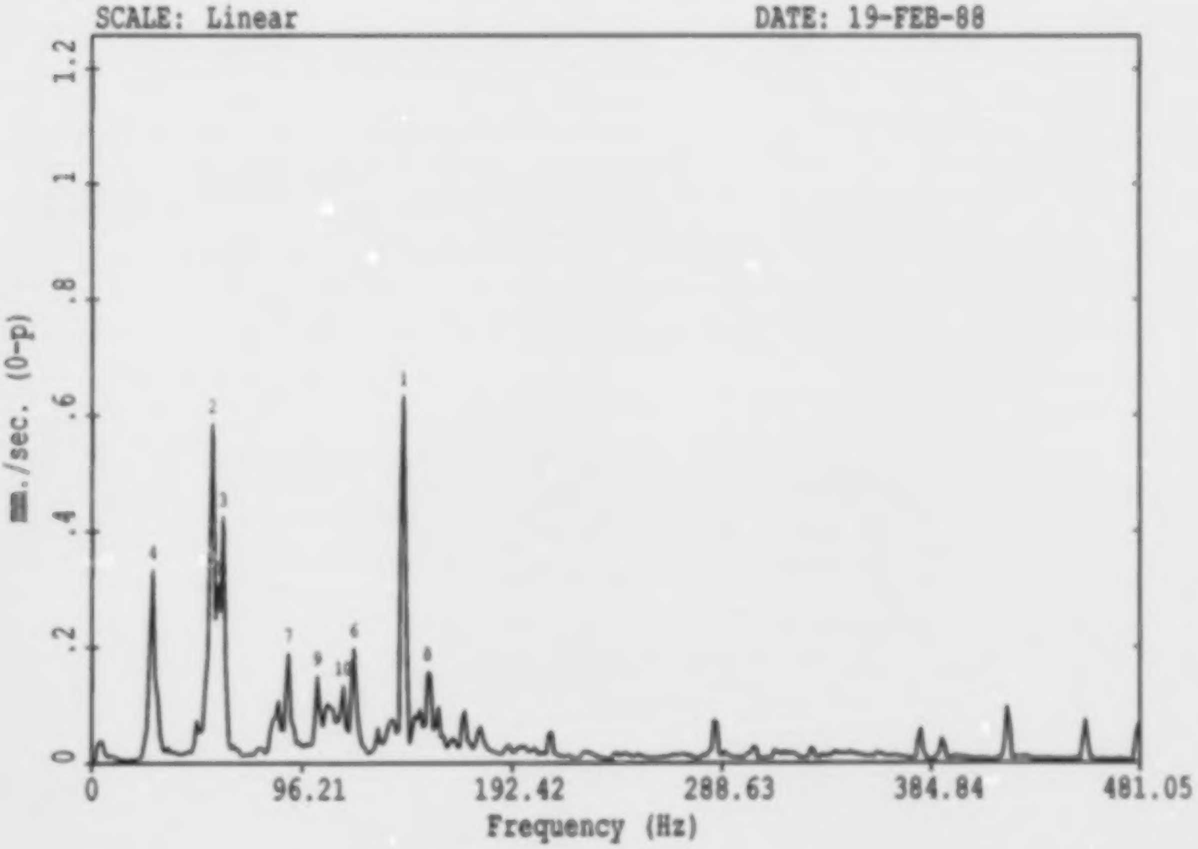


FIGURE C3

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.75
2	56.5	0.58
3	60.1	0.46
4	27.7	0.37
5	120.3	0.23
6	111.8	0.17
7	115.5	0.15
8	90.2	0.15
9	156.3	0.15
10	84.2	0.12

SCALE: Linear DATE: 19-FEB-88

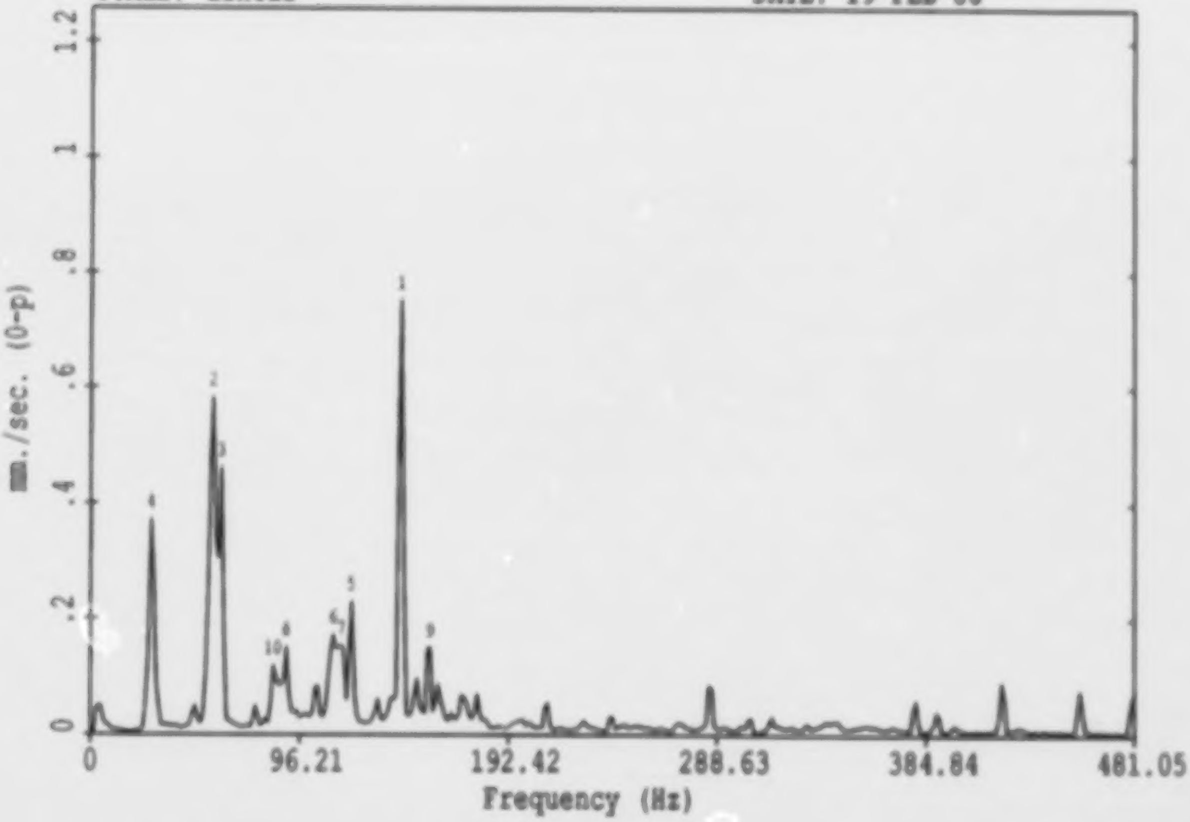


FIGURE C4

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.76
2	60.1	0.65
3	30.1	0.23
4	120.3	0.23
5	150.3	0.16
6	157.5	0.16
7	75.8	0.13
8	286.2	0.12
9	180.4	0.10
10	90.2	0.09

SCALE: Linear

DATE: 19-FEB-88

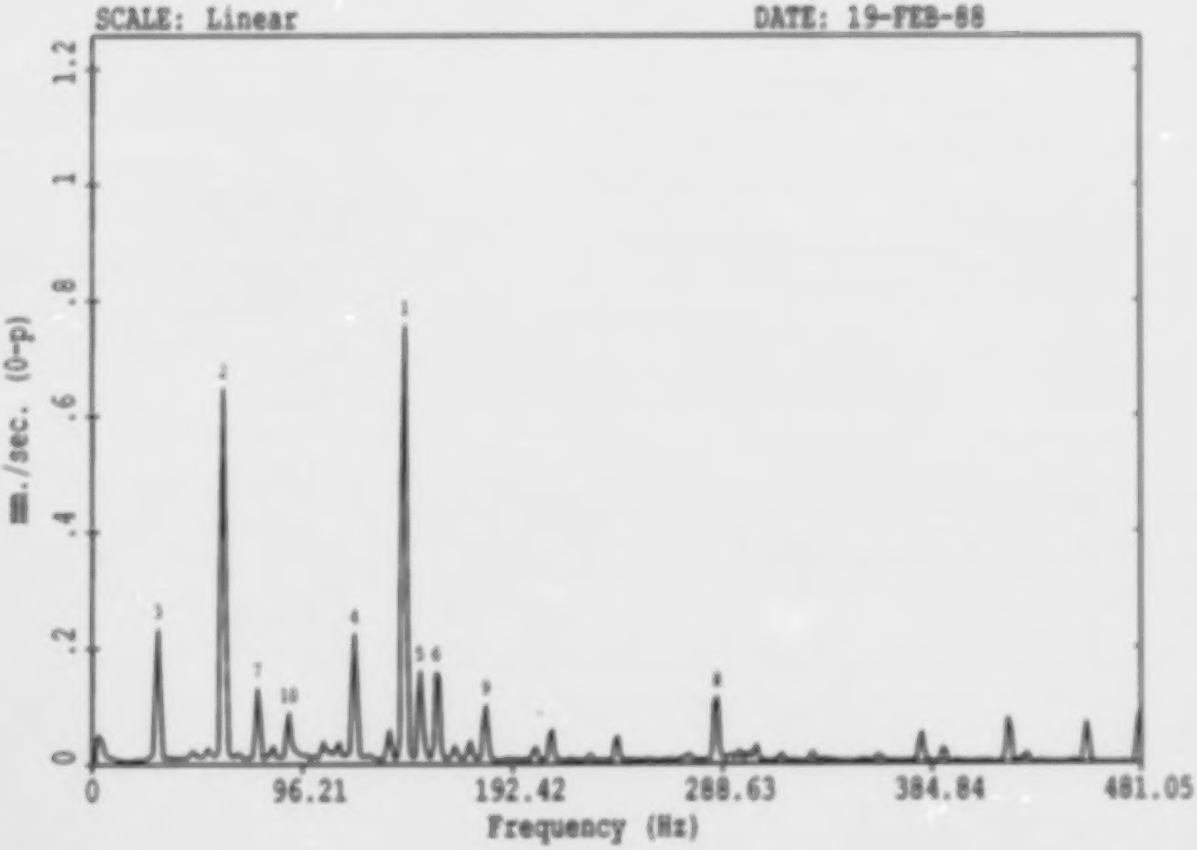


FIGURE C5

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.93
2	120.3	0.28
3	150.3	0.26
4	75.8	0.25
5	60.1	0.22
6	30.1	0.22
7	161.2	0.11
8	285.0	0.10
9	90.2	0.09
10	479.9	0.09

SCALE: Linear

DATE: 19-FEB-88

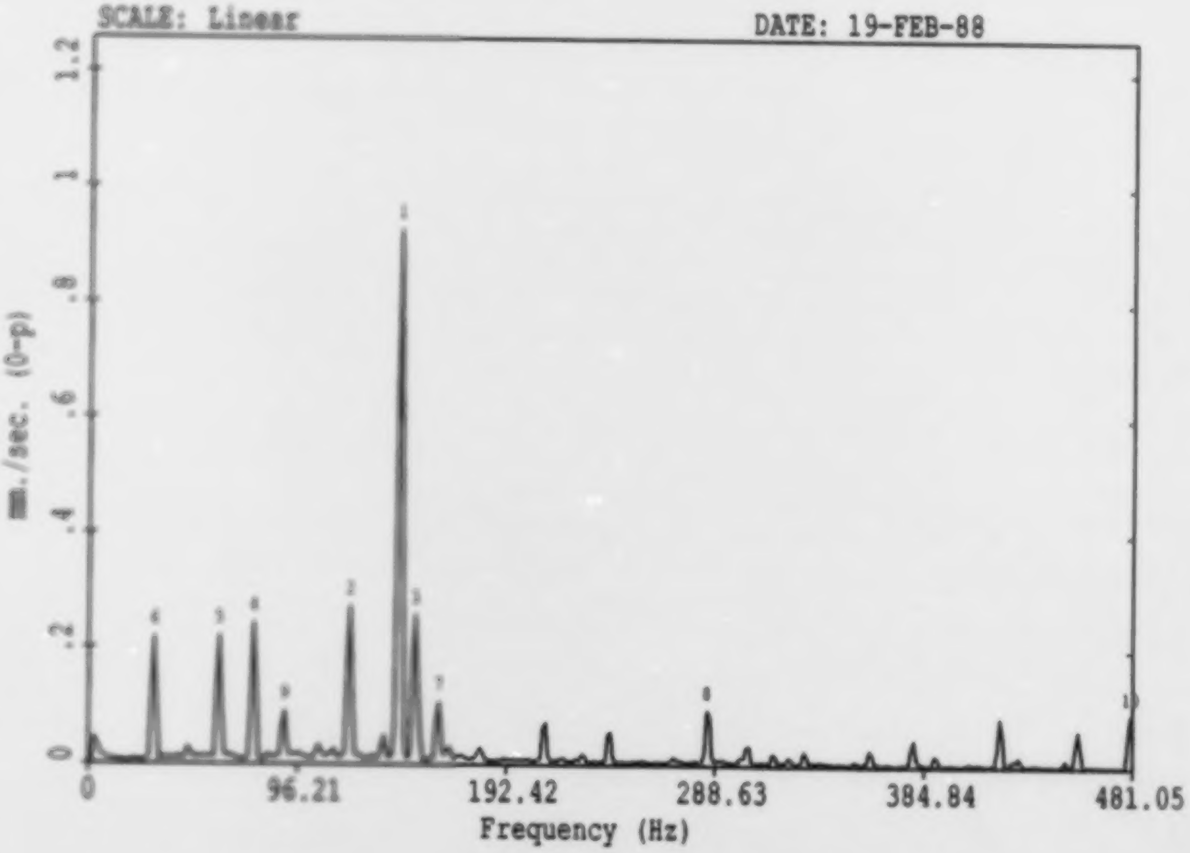


FIGURE C6

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.99
2	75.8	0.33
3	150.3	0.24
4	30.1	0.24
5	120.3	0.20
6	162.4	0.14
7	60.1	0.10
8	285.0	0.10
9	479.9	0.09
10	419.7	0.09

SCALE: Linear DATE: 19-FEB-88

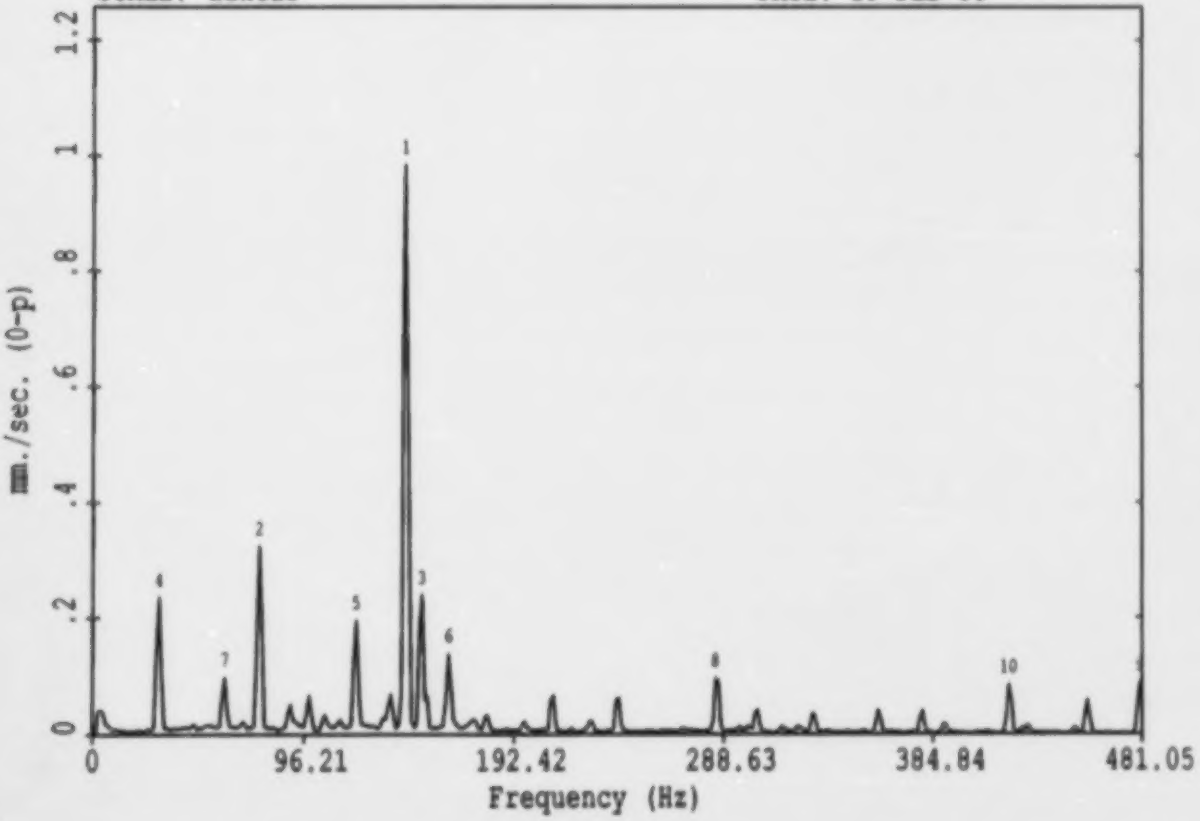


FIGURE C7

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	0.97
2	75.8	0.52
3	150.3	0.28
4	120.3	0.27
5	30.1	0.25
6	286.2	0.10
7	90.2	0.09
8	479.9	0.09
9	210.5	0.09
10	419.7	0.08

SCALE: Linear

DATE: 19-FEB-88

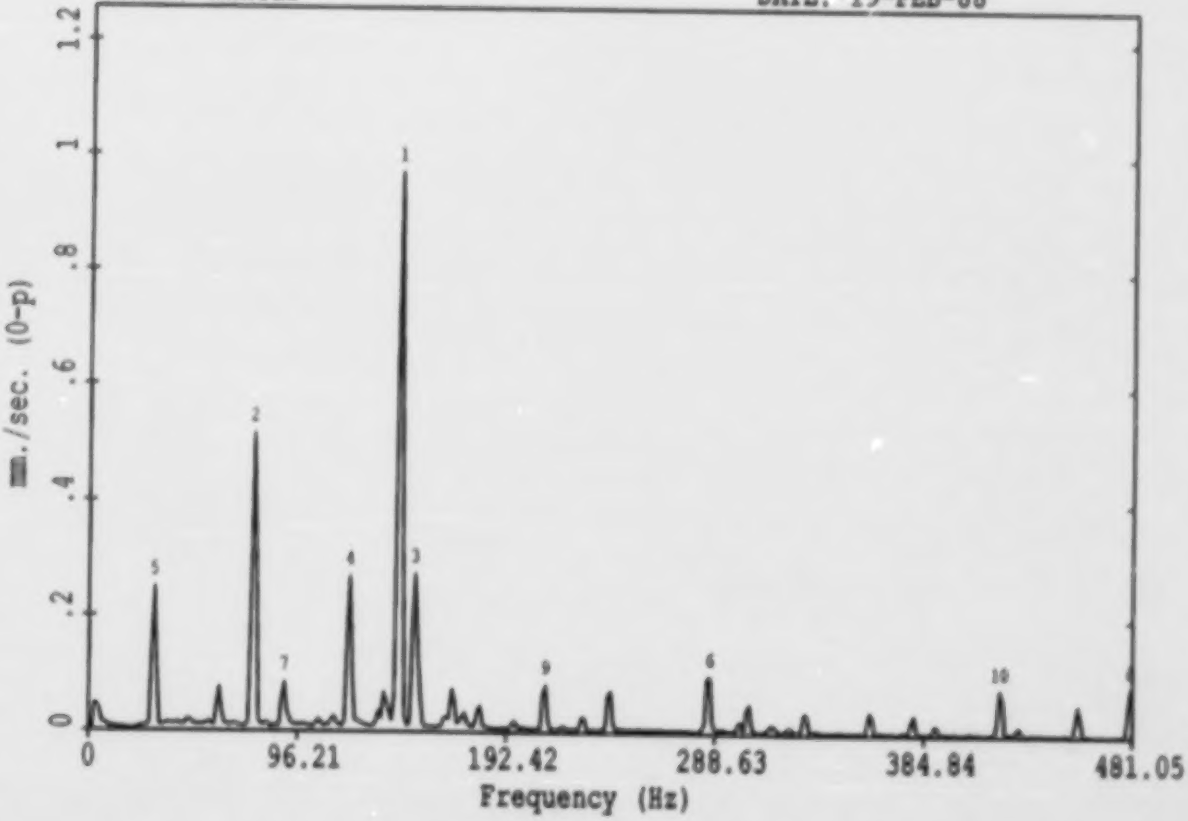


FIGURE C8

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	1.24
2	60.1	1.14
3	120.3	0.52
4	75.8	0.26
5	150.3	0.26
6	71.0	0.24
7	66.1	0.22
8	135.9	0.20
9	90.2	0.20
10	56.5	0.13

SCALE: Linear

DATE: 19-FEB-88

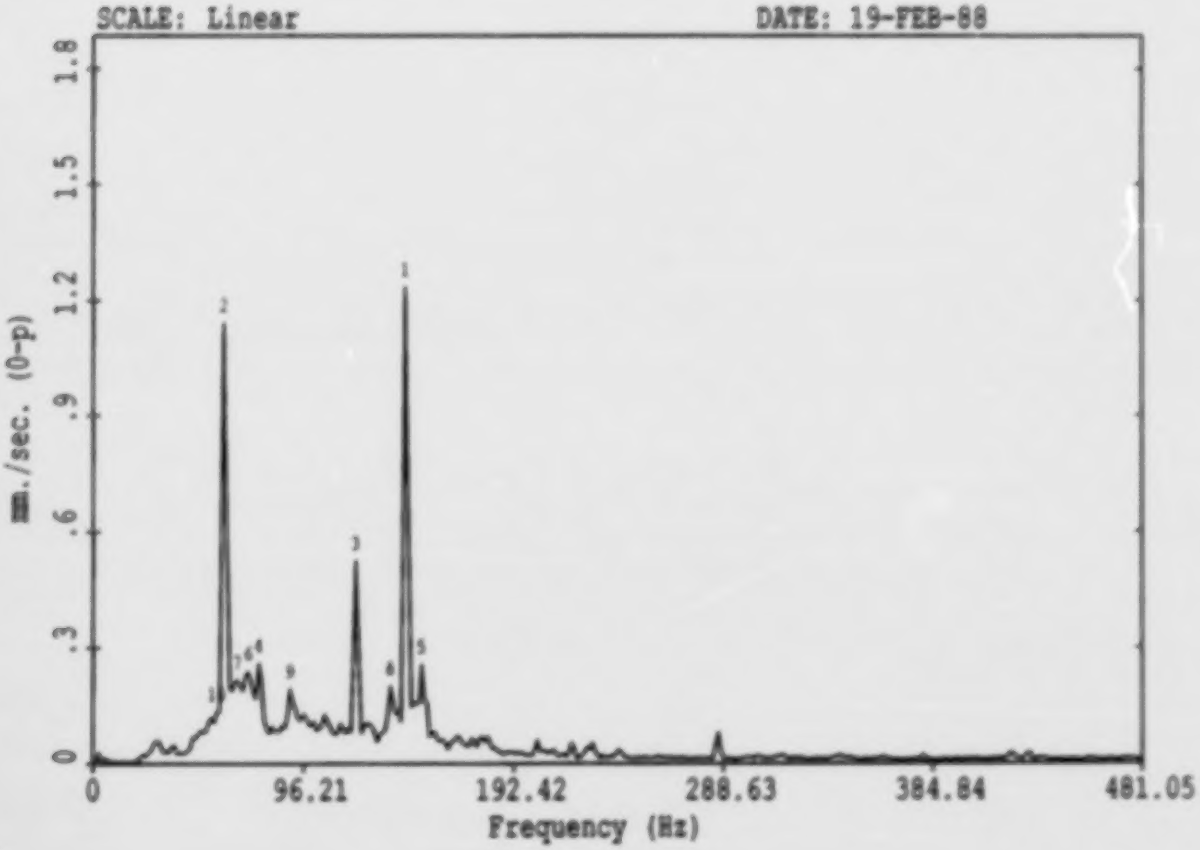


FIGURE C9

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	1.83
2	27.7	0.95
3	75.8	0.84
4	54.1	0.66
5	81.8	0.34
6	57.7	0.30
7	150.3	0.25
8	51.7	0.23
9	87.8	0.22
10	79.4	0.20

SCALE: Linear

DATE: 19-FEB-88

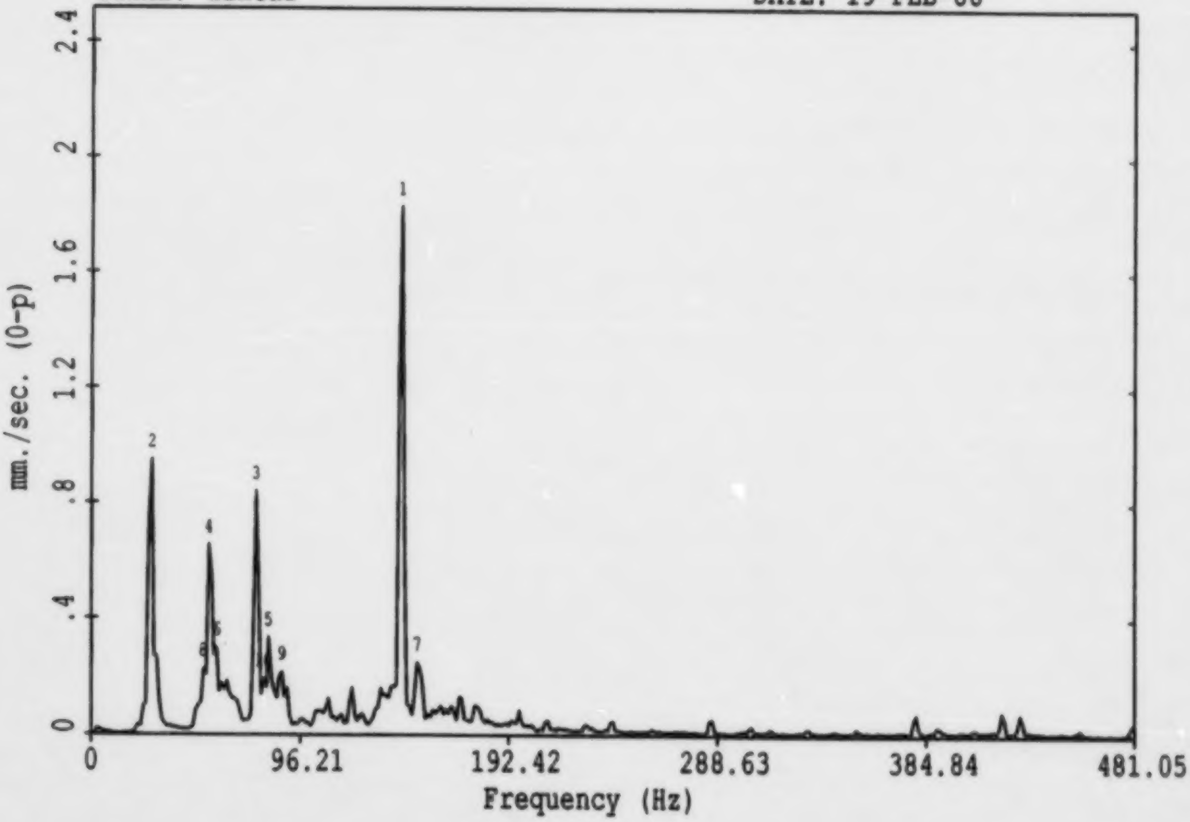


FIGURE C10

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	2.63
2	27.7	0.98
3	75.8	0.69
4	150.3	0.53
5	55.3	0.52
6	57.7	0.47
7	60.1	0.24
8	135.9	0.23
9	90.2	0.23
10	110.6	0.22

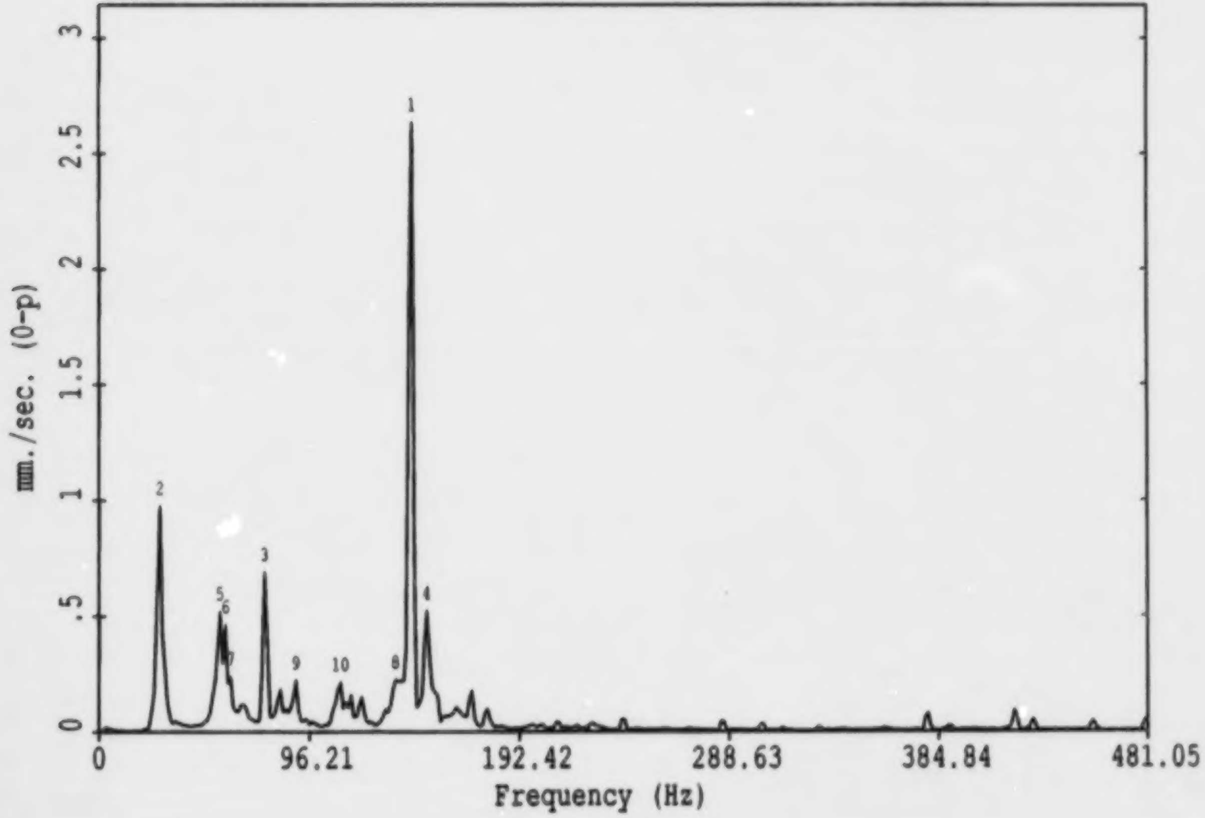

SCALE: Linear DATE: 19-FEB-88

FIGURE C11

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	2.87
2	27.7	1.04
3	75.8	0.66
4	150.3	0.64
5	57.7	0.44
6	111.8	0.29
7	120.3	0.25
8	90.2	0.23
9	155.1	0.20
10	84.2	0.18

SCALE: Linear

DATE: 19-FEB-88

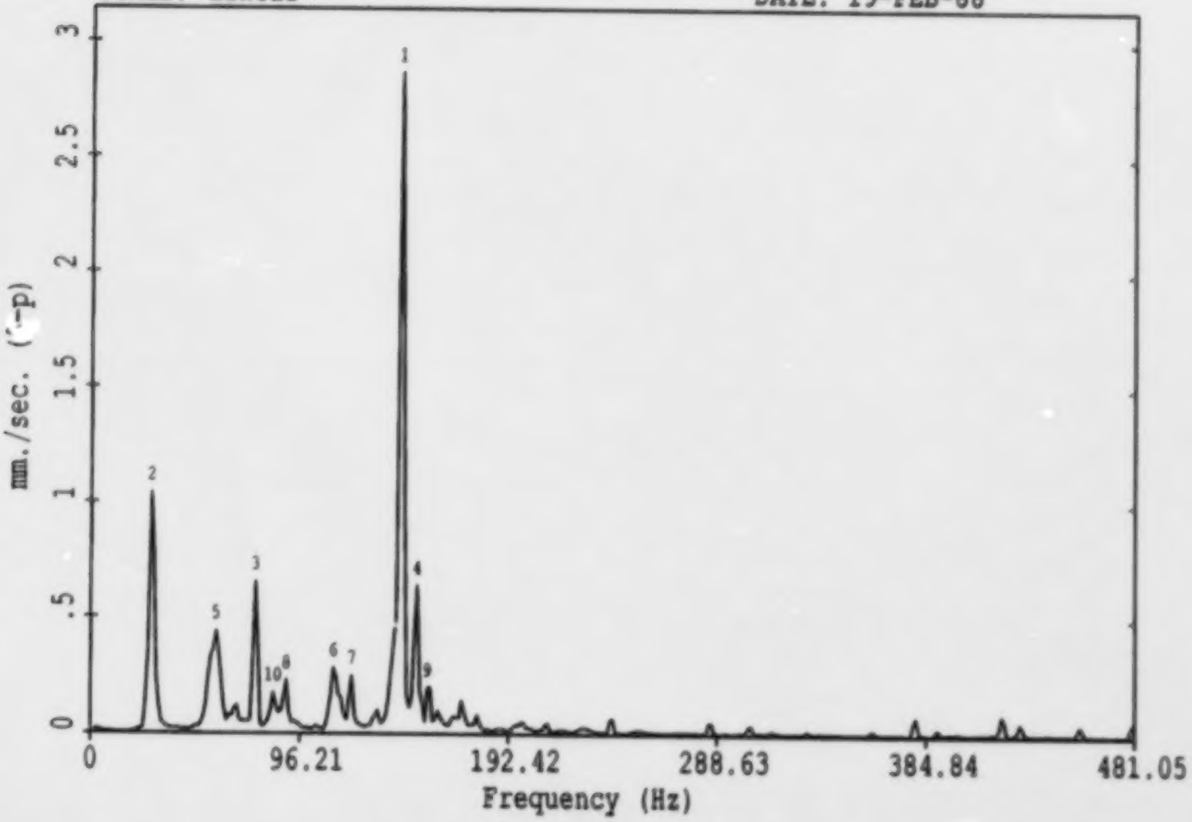


FIGURE C12

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.29
2	150.3	0.74
3	60.1	0.59
4	75.8	0.57
5	30.1	0.55
6	120.3	0.30
7	157.5	0.26
8	90.2	0.17
9	240.5	0.10
10	135.9	0.09

SCALE: Linear DATE: 19-FEB-88

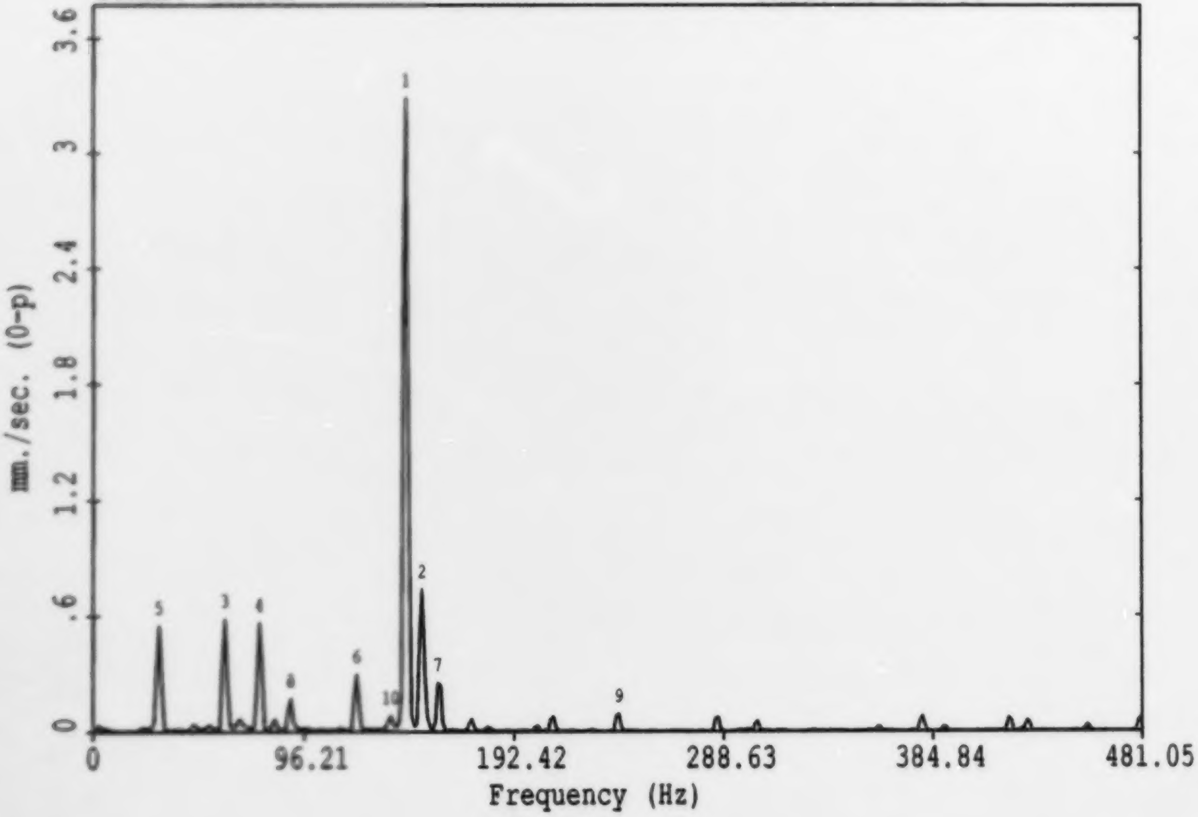


FIGURE C13

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.61
2	150.3	1.04
3	60.1	0.66
4	75.8	0.55
5	30.1	0.37
6	120.3	0.27
7	90.2	0.18
8	161.2	0.14
9	135.9	0.12
10	210.5	0.11

SCALE: Linear

DATE: 19-FEB-88

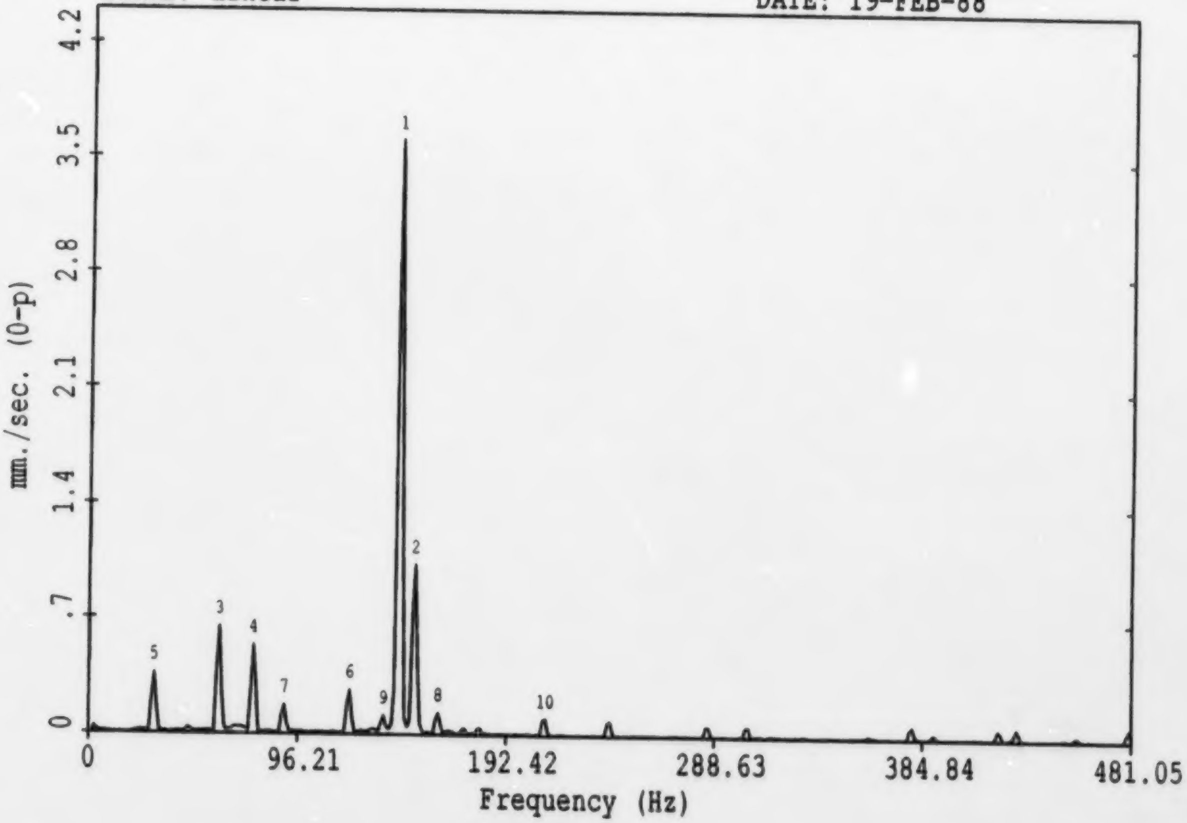


FIGURE C14

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.70
2	150.3	0.99
3	60.1	0.70
4	75.8	0.51
5	30.1	0.28
6	135.9	0.23
7	90.2	0.19
8	120.3	0.16
9	162.4	0.13
10	210.5	0.12

SCALE: Linear

DATE: 19-FEB-88

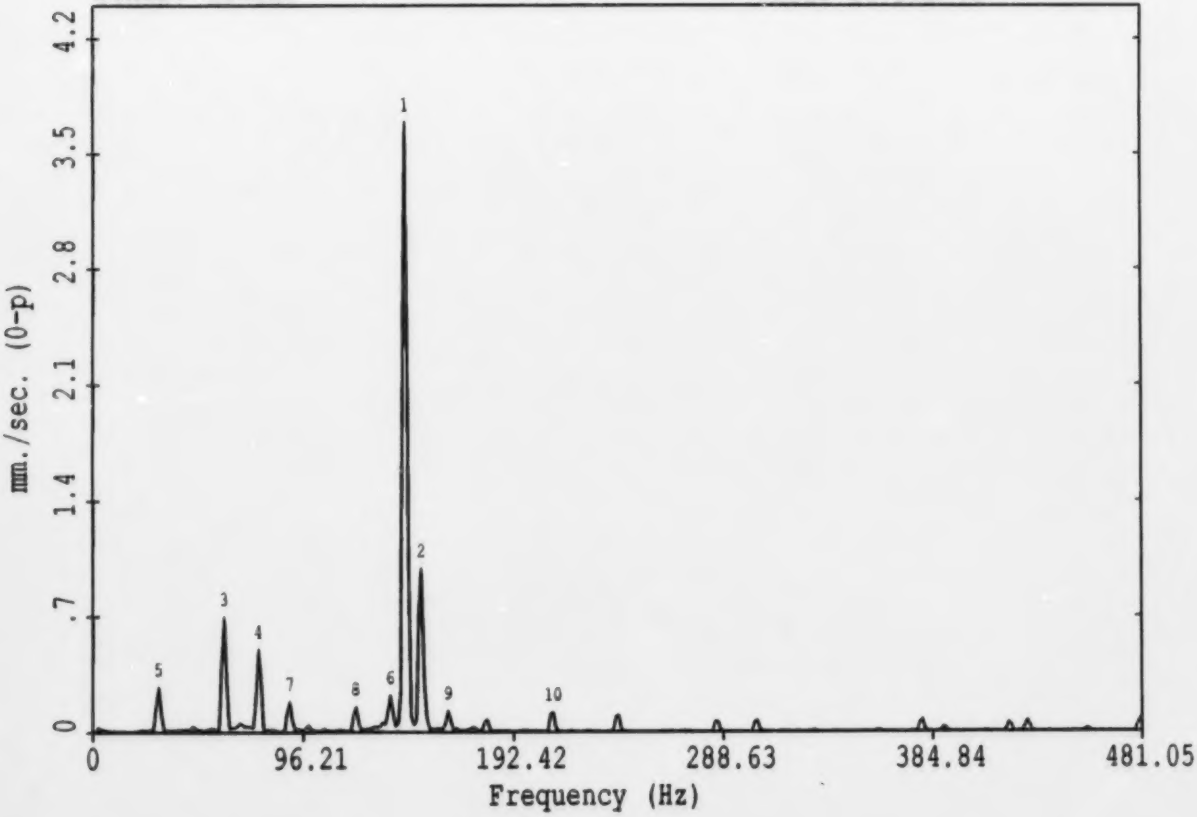


FIGURE C15

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.52
2	150.3	1.11
3	60.1	0.71
4	75.8	0.45
5	30.1	0.25
6	90.2	0.21
7	135.9	0.21
8	210.5	0.17
9	120.3	0.16
10	240.5	0.12

SCALE: Linear

DATE: 19-FEB-88

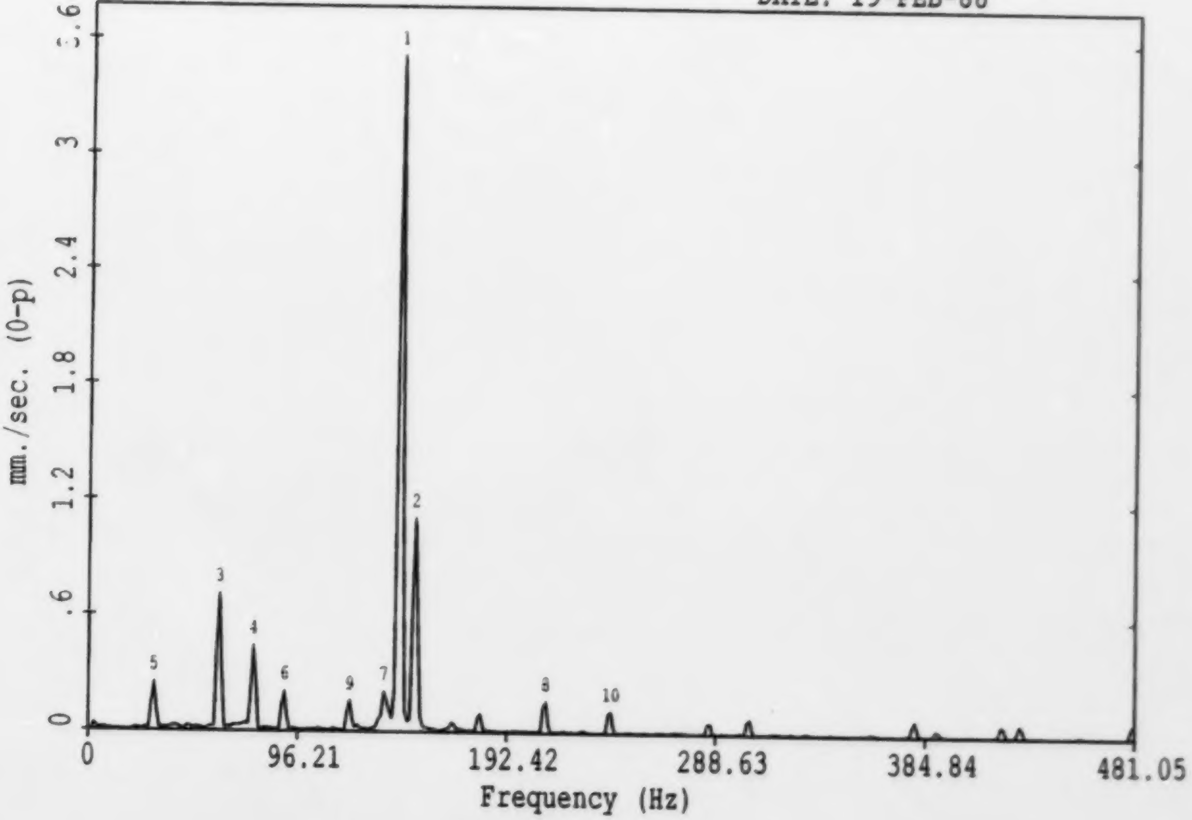


FIGURE C16

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	1.23
2	150.3	0.40
3	120.3	0.37
4	56.5	0.17
5	30.1	0.16
6	135.9	0.15
7	139.5	0.14
8	180.4	0.12
9	60.1	0.12
10	50.5	0.12

SCALE: Linear DATE: 19-FEB-88

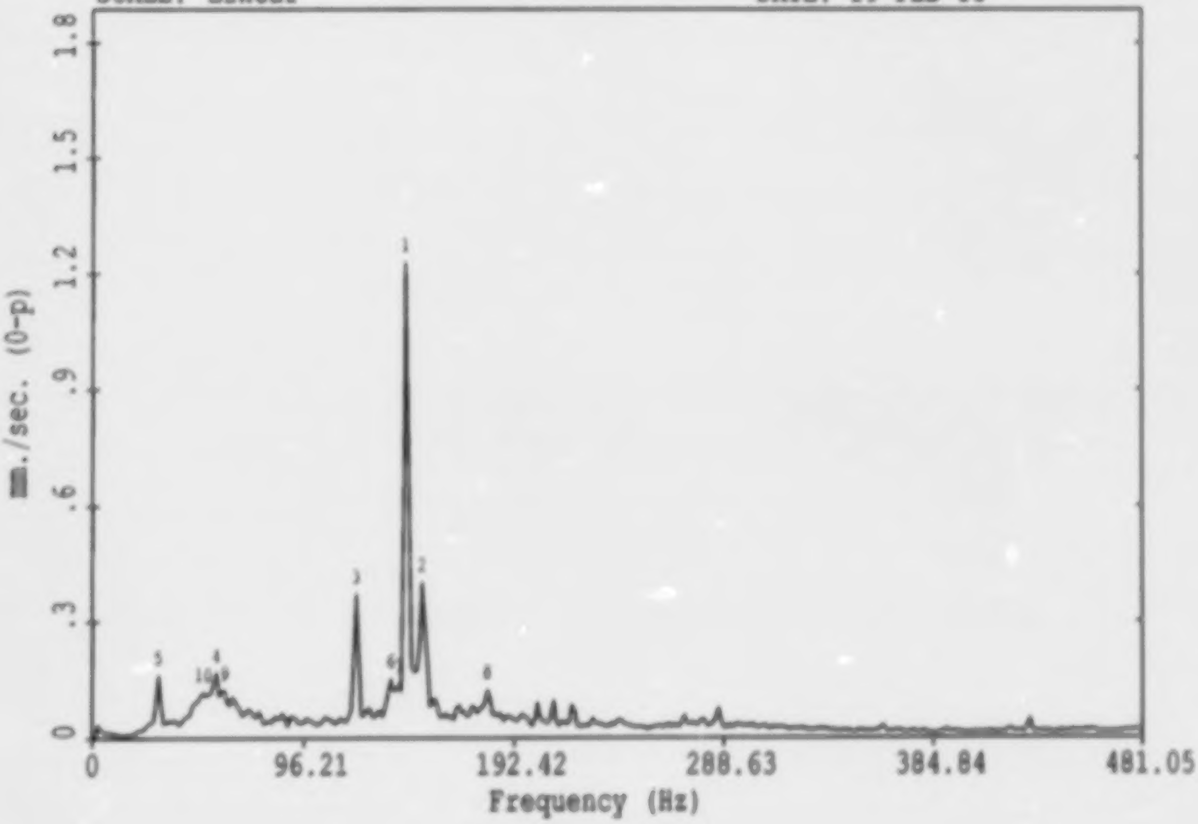


FIGURE C17

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	1.68
2	54.1	0.79
3	57.7	0.73
4	90.2	0.73
5	27.7	0.59
6	60.1	0.51
7	30.1	0.33
8	81.8	0.30
9	150.3	0.29
10	62.5	0.28

SCALE: Linear

DATE: 19-FEB-88

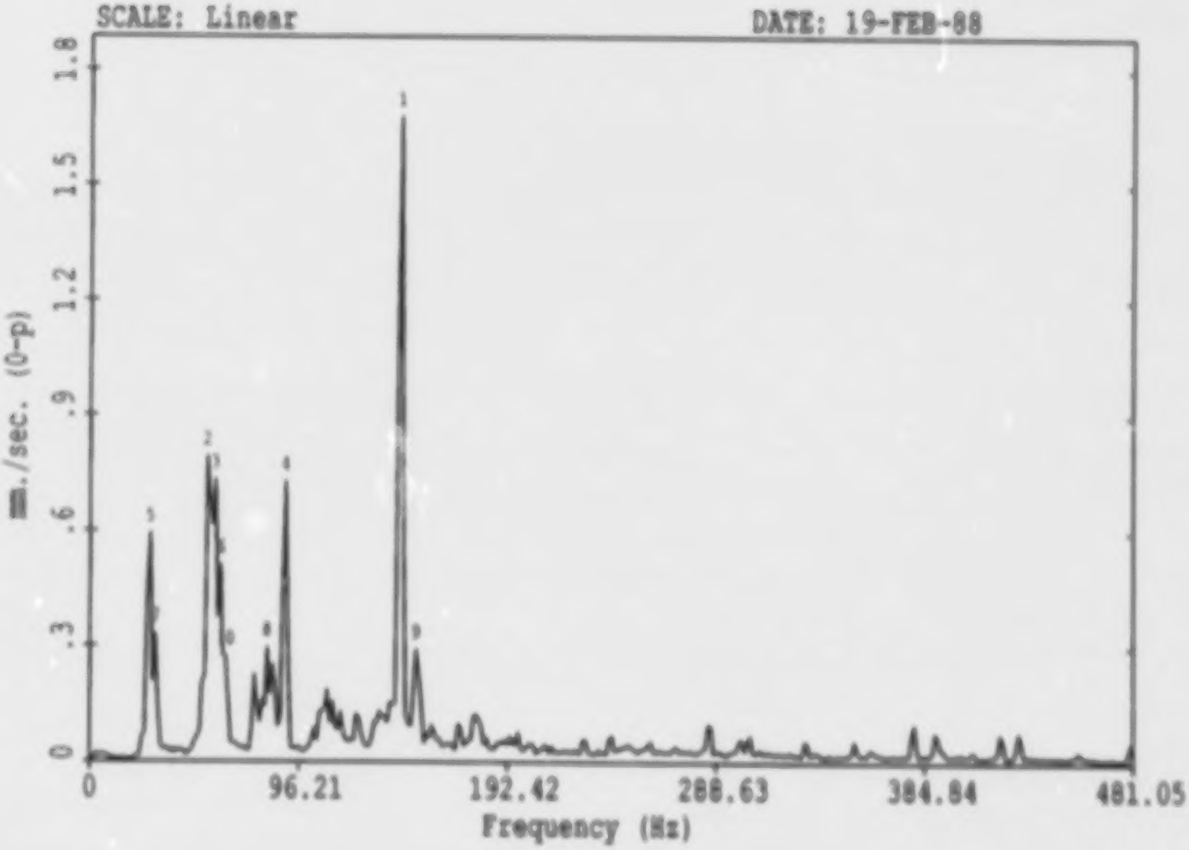


FIGURE C18

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	2.59
2	60.1	1.13
3	55.3	0.97
4	150.3	0.55
5	90.2	0.52
6	27.7	0.43
7	135.9	0.22
8	75.8	0.22
9	115.5	0.19
10	120.3	0.17

SCALE: Linear DATE: 19-FEB-88

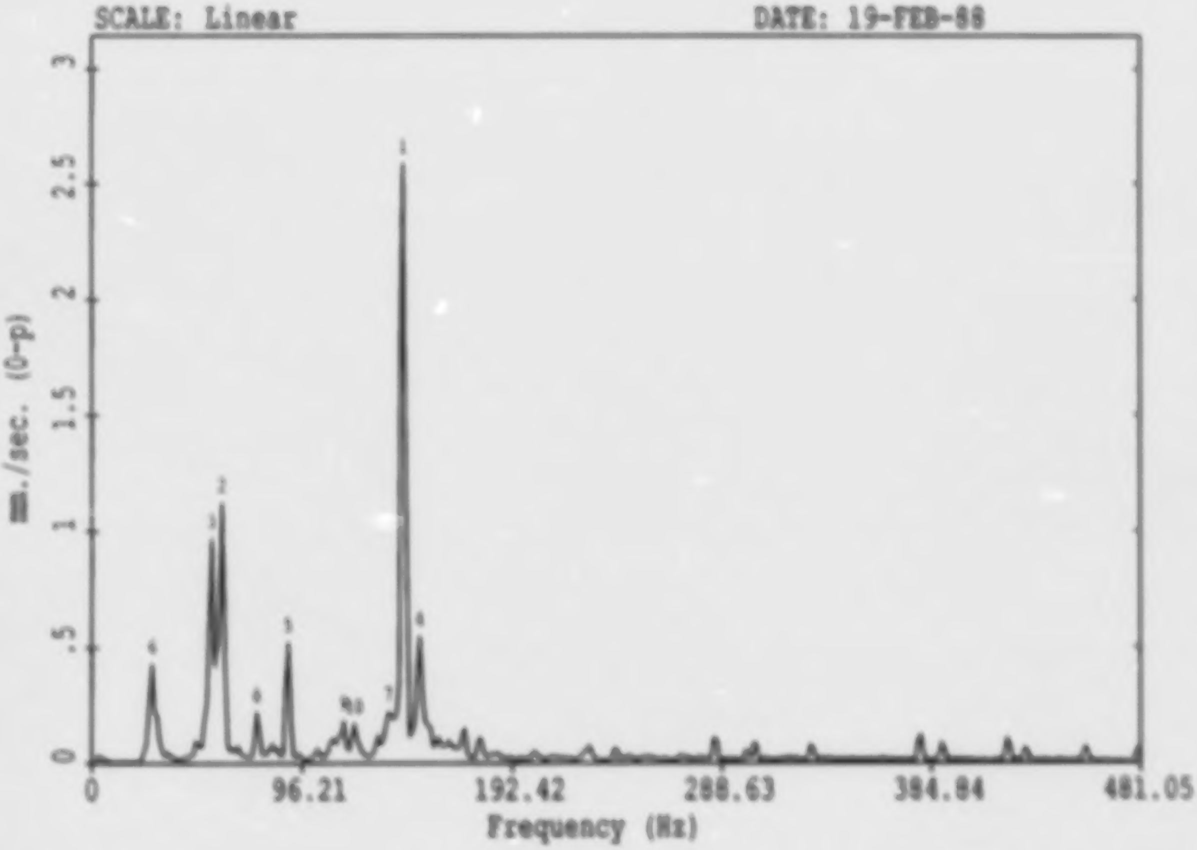


FIGURE C19

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	2.82
2	60.1	1.21
3	56.5	1.02
4	150.3	0.62
5	90.2	0.49
6	27.7	0.43
7	120.3	0.34
8	75.8	0.27
9	156.3	0.22
10	111.8	0.17

SCALE: Linear

DATE: 19-FEB-88

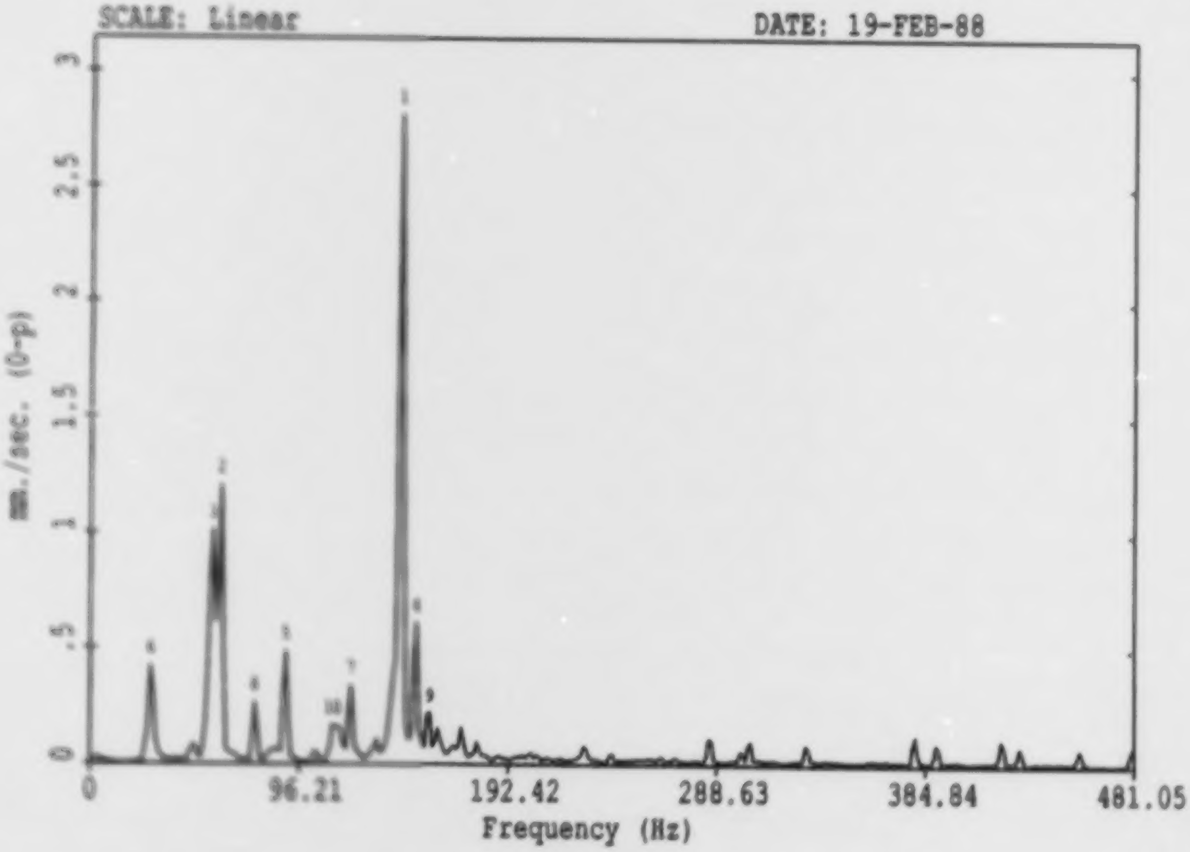


FIGURE C20

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.26
2	60.1	1.47
3	150.3	0.74
4	75.8	0.45
5	30.1	0.41
6	157.5	0.28
7	120.3	0.28
8	90.2	0.23
9	286.2	0.14
10	380.0	0.14

SCALE: Linear DATE: 19-FEB-88

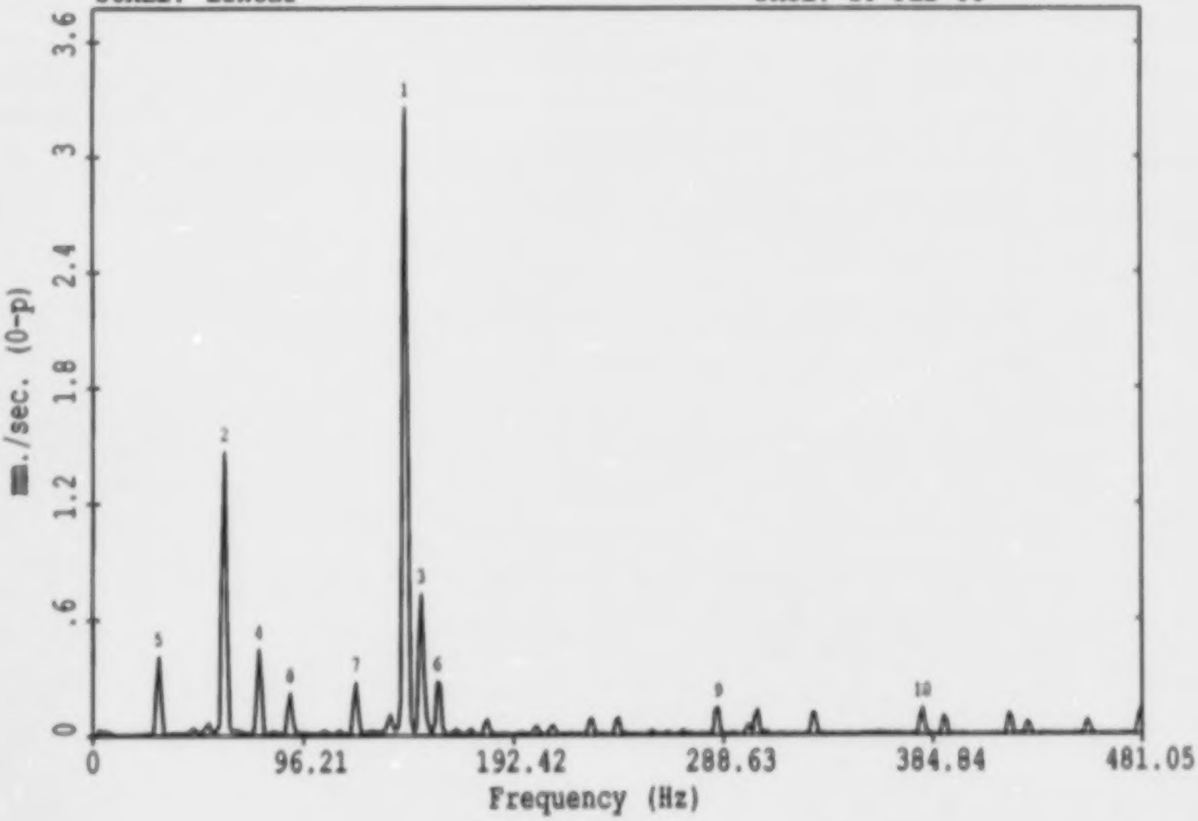


FIGURE C21

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.66
2	150.3	1.07
3	75.8	0.57
4	60.1	0.52
5	30.1	0.46
6	120.3	0.34
7	161.2	0.21
8	285.0	0.17
9	135.9	0.15
10	304.3	0.15

SCALE: Linear

DATE: 19-FEB-88

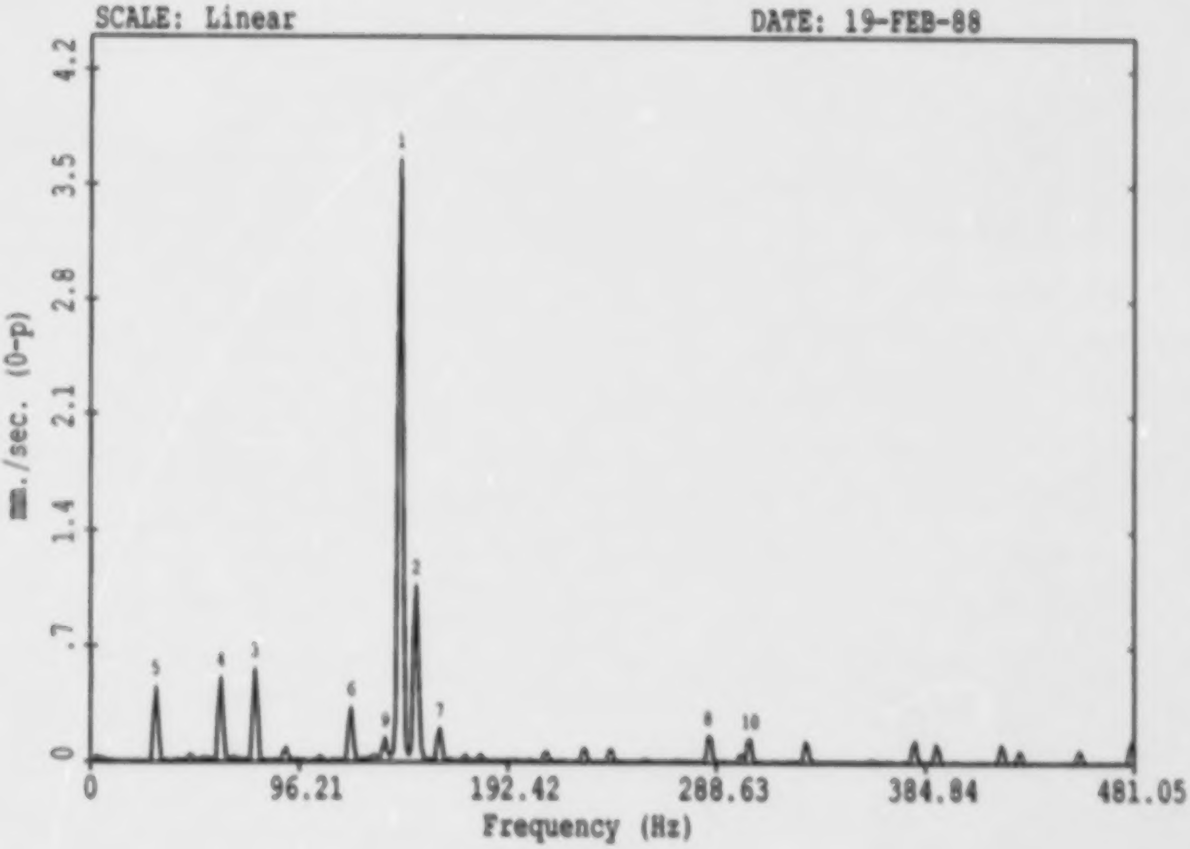


FIGURE C22

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.79
2	150.3	1.03
3	75.8	0.67
4	30.1	0.49
5	135.9	0.27
6	120.3	0.21
7	162.4	0.19
8	285.0	0.18
9	304.3	0.16
10	479.9	0.15

SCALE: Linear

DATE: 19-FEB-88

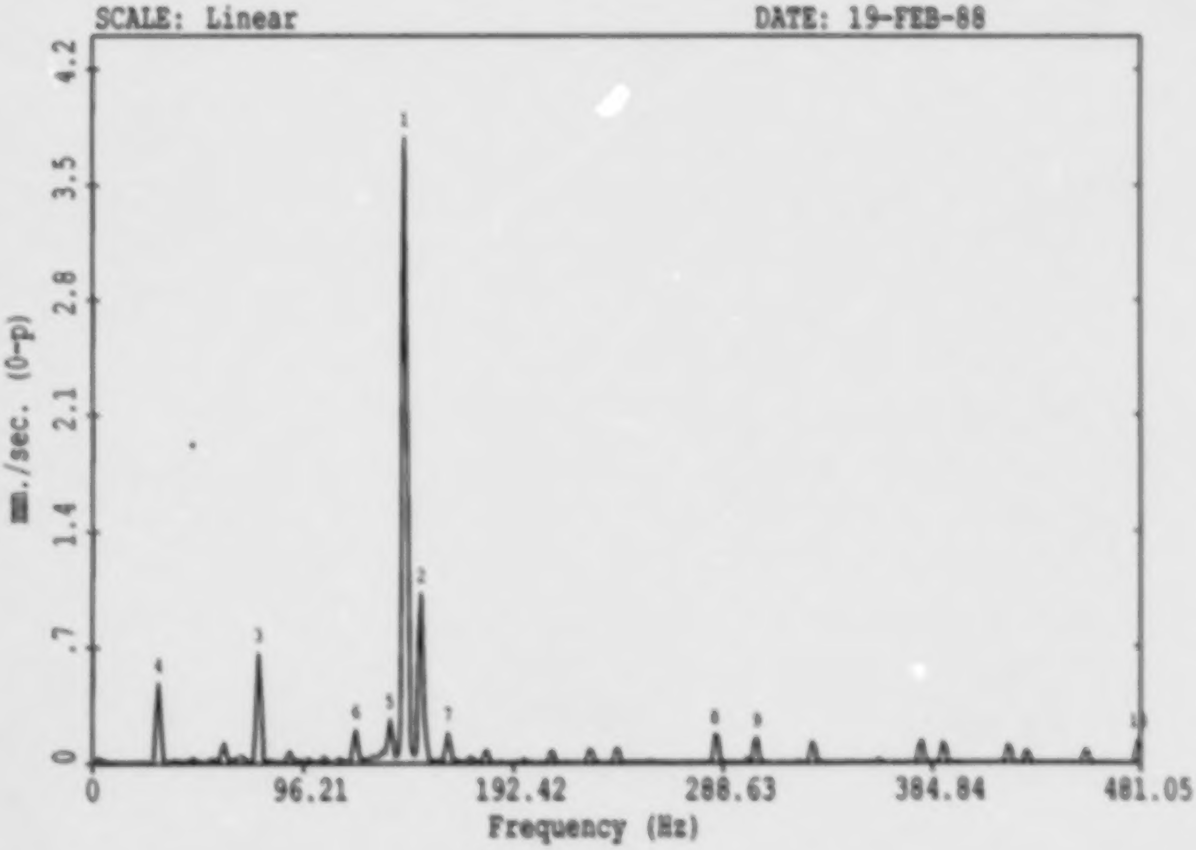


FIGURE C23

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : REDUCTION GEARBOX CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.67
2	150.3	1.14
3	75.8	0.94
4	30.1	0.52
5	120.3	0.33
6	135.9	0.25
7	304.3	0.18
8	286.2	0.17
9	380.0	0.15
10	479.9	0.14

SCALE: Linear

DATE: 19-FEB-88

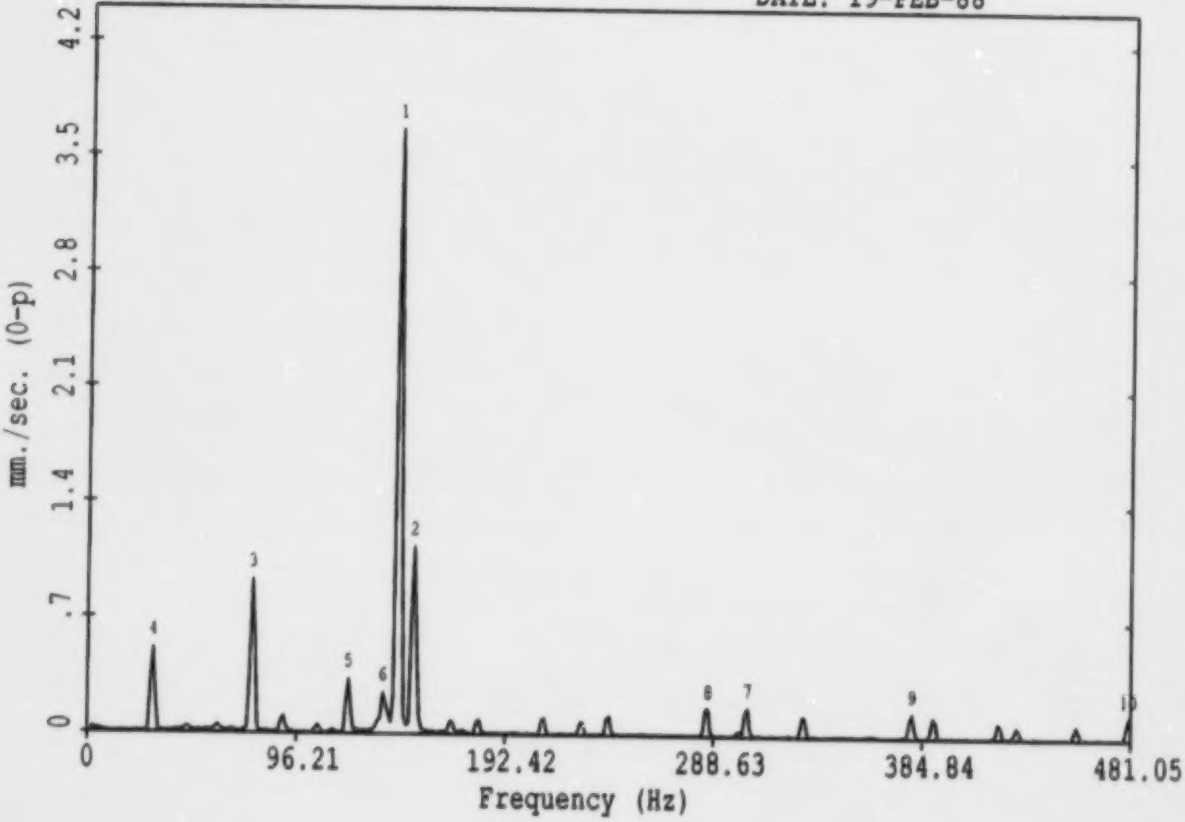


FIGURE C24

APPENDIX D

POWER TURBINE VELOCITY AND DISPLACEMENT SPECTRA

TABLE D1
DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2 - POWER TURBINE FIGURE NUMBERS OF VELOCITY AND DISPLACEMENT SPECTRA

Measurement		FFT Spectrum Figure No. Load (MW)							
		0	1	1.5	2	3	4	5	6.8
Bearing No 5 Casing Velocity	Vertical Direction	D1	D2	D3	D4	D5	D6	D7	D8
	Horizontal Direction	D9	D10	D11	D12	D13	D14	D15	D16
	Axial Direction	D17	D18	D19	D20	D21	D22	D23	D24
Bearing No 4 Shaft Displacement	Vertical Direction	D25	D26	D27	D28	D29	D30	D31	D32
	Horizontal Direction	D33	D34	D35	D36	D37	D38	D39	D40
Bearing No 5 Shaft Displacement	Vertical Direction	D41	D42	D43	D44	D45	D46	D47	D48
	Horizontal Direction	D49	D50	D51	D52	D53	D54	D55	D56

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY VERTICAL
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	4.28
2	147.9	2.19
3	75.8	1.07
4	286.2	0.77
5	60.1	0.55
6	66.1	0.41
7	63.7	0.37
8	86.6	0.36
9	30.1	0.31
10	32.5	0.27

SCALE: Linear DATE: 19-FEB-88

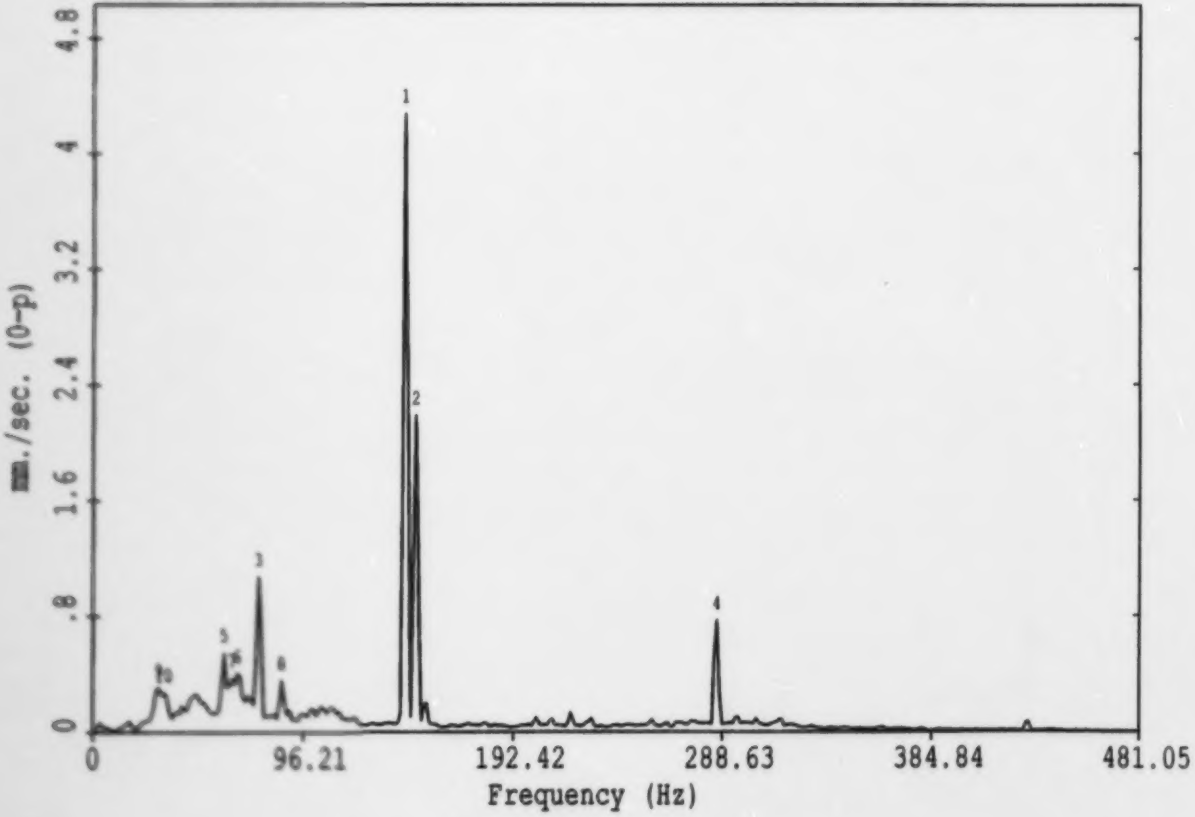


FIGURE D1

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY VERTICAL
PROCESS CONDITION : LOAD 1 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	4.02
2	152.7	1.51
3	54.1	1.44
4	285.0	0.94
5	60.1	0.81
6	75.8	0.74
7	81.8	0.70
8	64.9	0.67
9	27.7	0.56
10	79.4	0.55

SCALE: Linear

DATE: 19-FEB-88

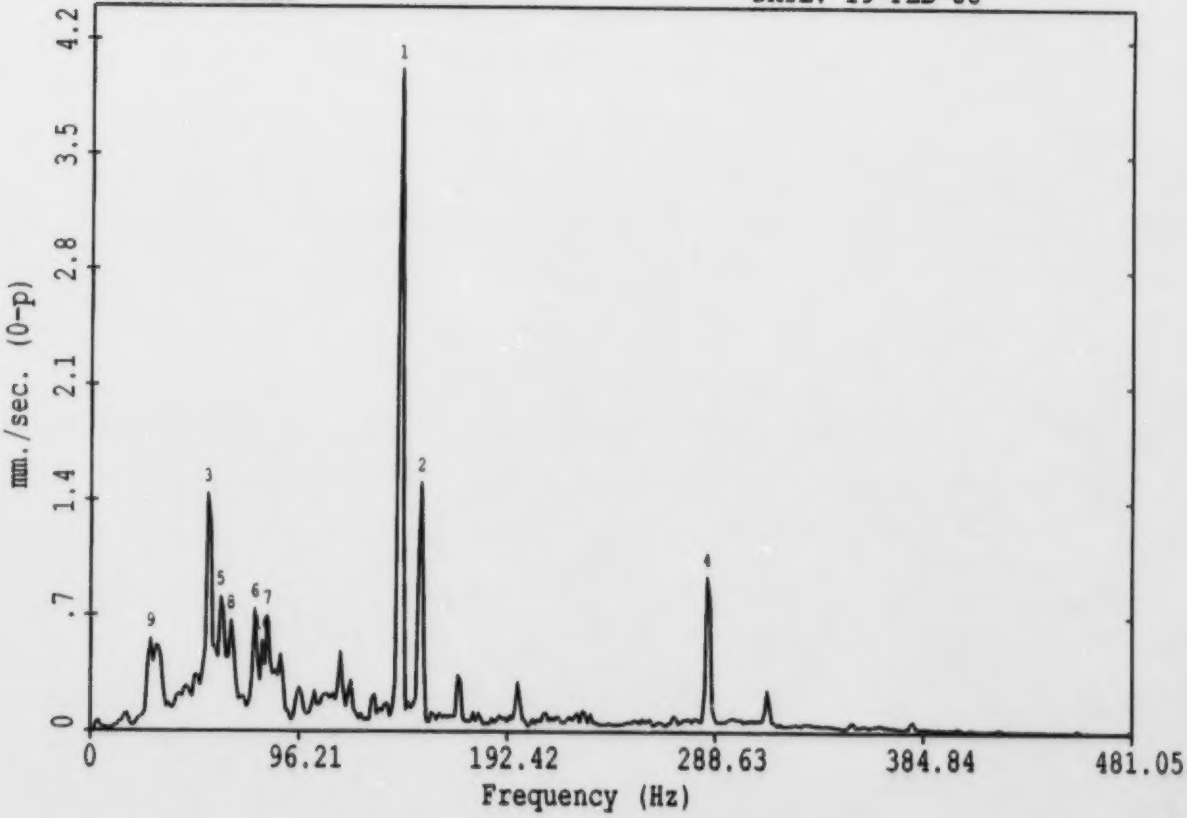


FIGURE D2

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY VERTICAL
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	4.08
2	153.9	1.18
3	55.3	1.14
4	75.8	1.03
5	60.1	0.86
6	27.7	0.70
7	115.5	0.66
8	64.9	0.61
9	285.0	0.60
10	83.0	0.55

SCALE: Linear DATE: 19-FEB-88

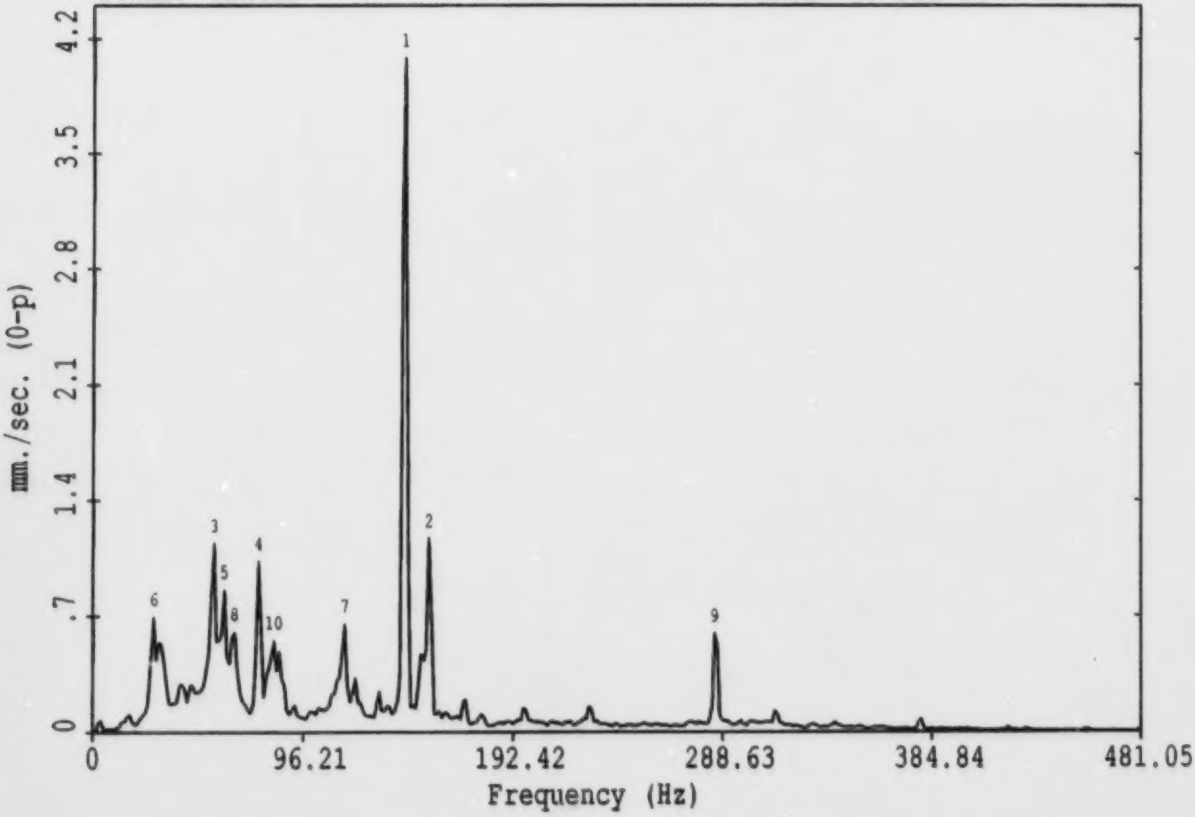


FIGURE D3

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY VERTICAL
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	4.86
2	75.8	1.14
3	56.5	1.06
4	155.1	0.84
5	60.1	0.79
6	27.7	0.77
7	150.3	0.62
8	114.3	0.53
9	64.9	0.53
10	285.0	0.45

SCALE: Linear

DATE: 19-FEB-88

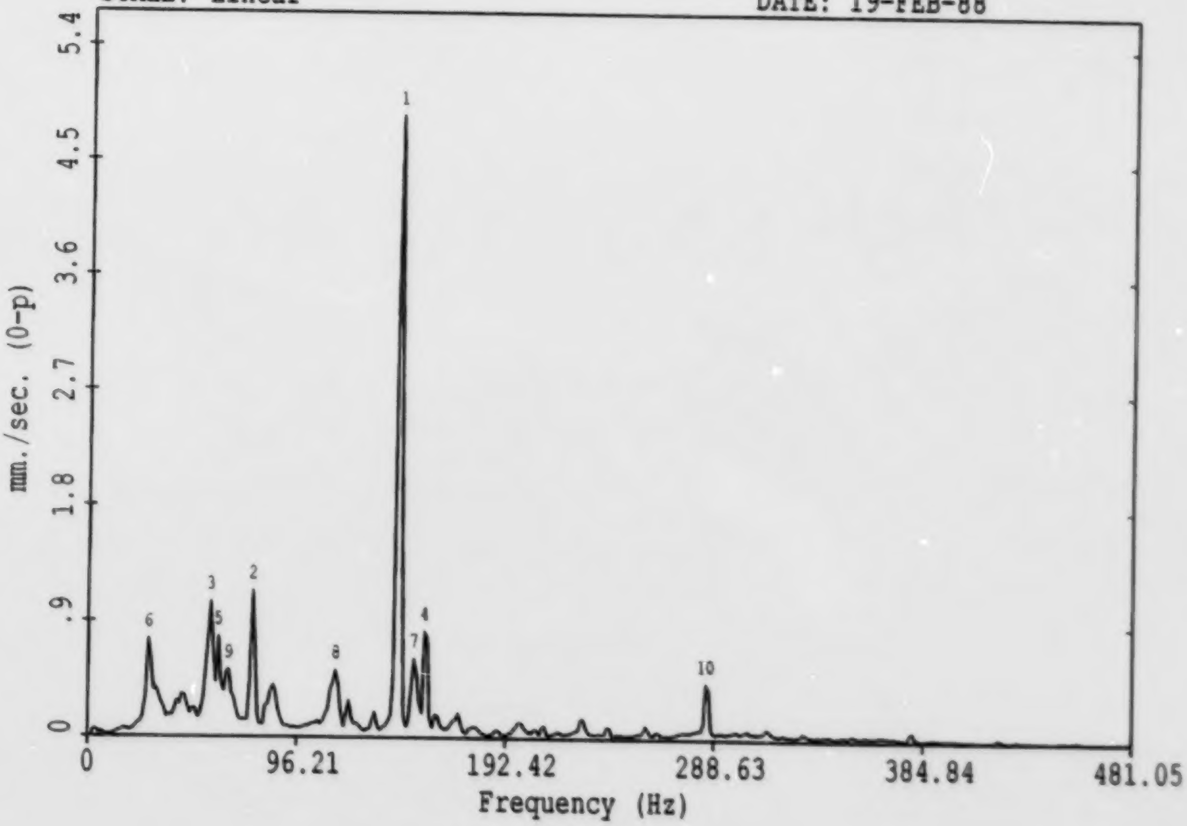


FIGURE D4

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY VERTICAL
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	5.54
2	143.1	5.41
3	60.1	4.56
4	75.8	2.19
5	150.3	0.90
6	157.5	0.62
7	90.2	0.61
8	63.7	0.45
9	120.3	0.45
10	44.5	0.37

SCALE: Linear

DATE: 19-FEB-88

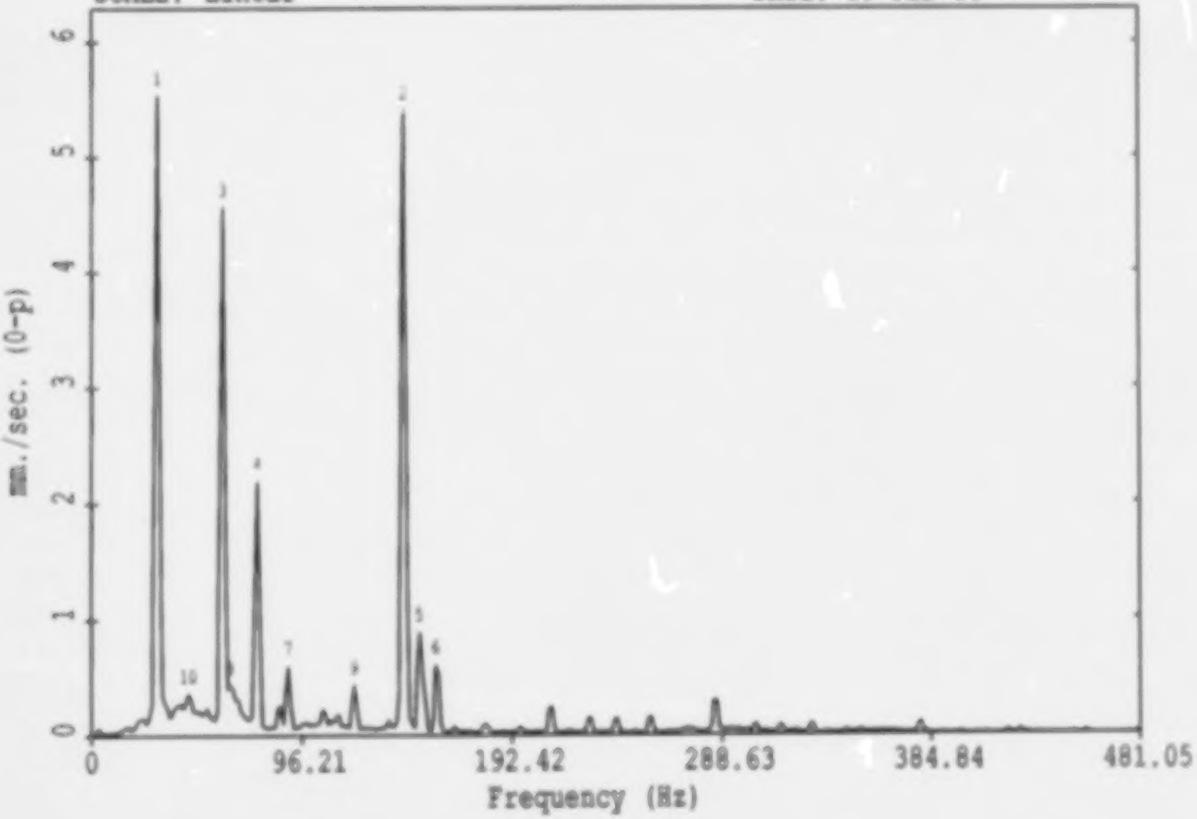


FIGURE D5

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY VERTICAL
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	6.67
2	143.1	5.71
3	75.8	2.78
4	60.1	1.92
5	150.3	1.11
6	161.2	0.78
7	90.2	0.68
8	285.0	0.60
9	105.8	0.48
10	45.7	0.44

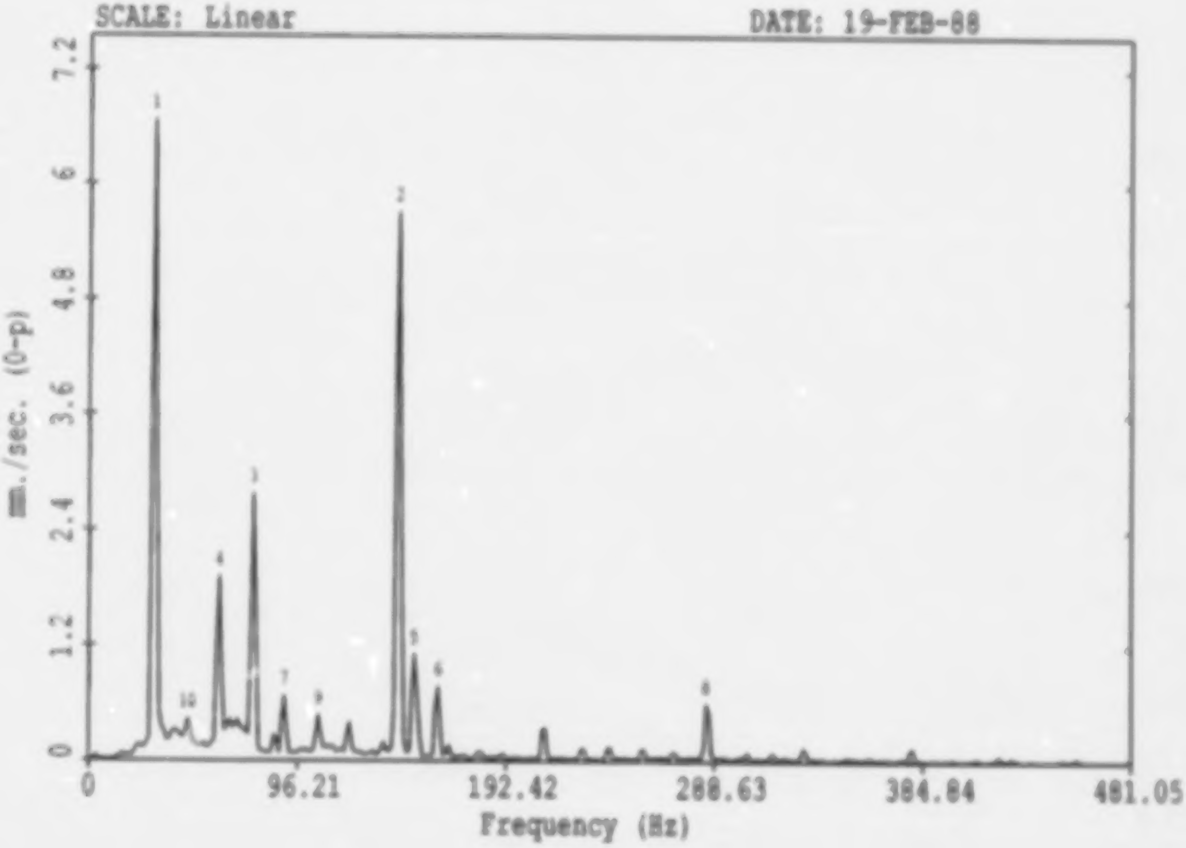


FIGURE D6

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY VERTICAL
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	6.89
2	143.1	5.72
3	75.8	3.53
4	150.3	1.02
5	162.4	0.87
6	60.1	0.75
7	285.0	0.65
8	105.8	0.57
9	90.2	0.53
10	120.3	0.48

SCALE: Linear

DATE: 19-FEB-88

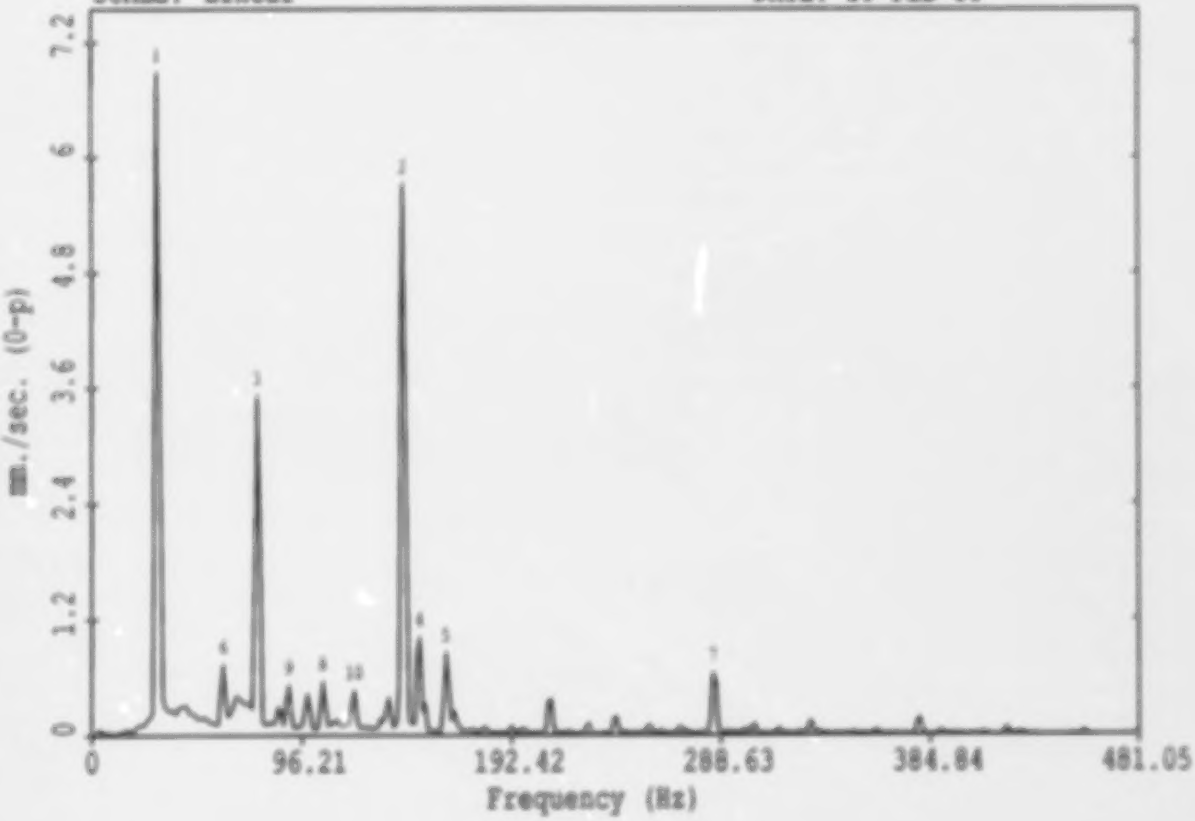


FIGURE D7

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY VERTICAL
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	6.21
2	143.1	5.42
3	75.8	5.35
4	60.1	1.90
5	167.2	1.48
6	150.3	1.05
7	285.0	0.74
8	135.9	0.43
9	45.7	0.40
10	210.5	0.39

SCALE: Linear

DATE: 19-FEB-88

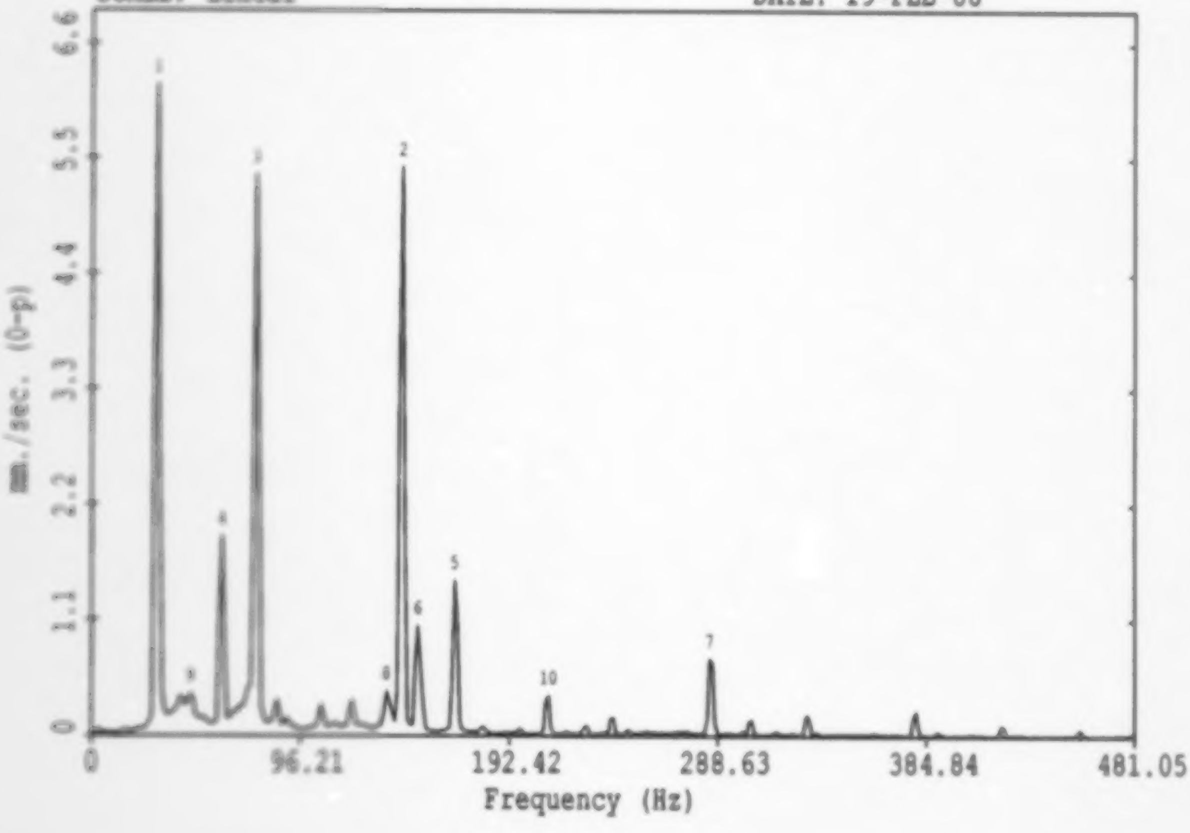


FIGURE D8

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY HORIZONTAL
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	4.43
2	75.8	1.37
3	147.9	1.11
4	30.1	0.83
5	60.1	0.63
6	63.7	0.40
7	67.3	0.39
8	152.7	0.31
9	71.0	0.31
10	95.0	0.26

SCALE: Linear

DATE: 19-FEB-88

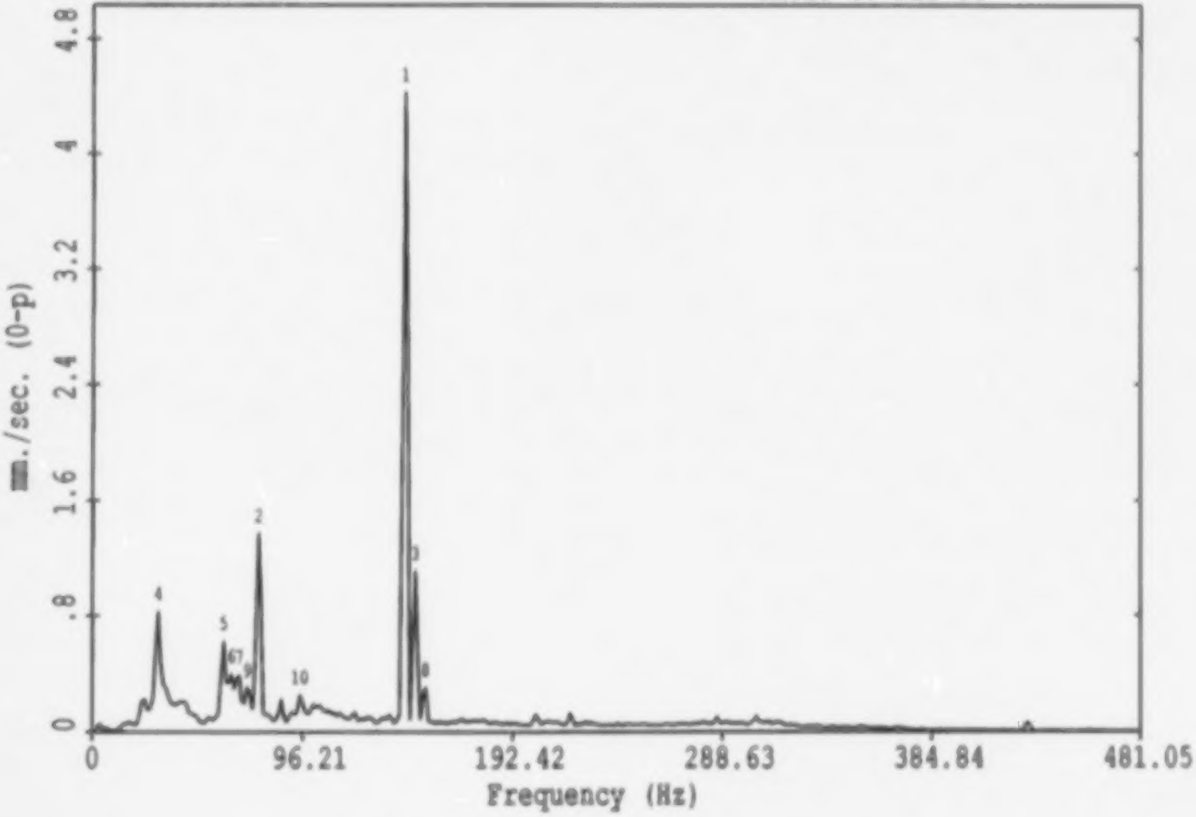


FIGURE D9

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY HORIZONTAL
PROCESS CONDITION : LOAD 1 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.88
2	75.8	1.28
3	30.1	1.15
4	60.1	1.07
5	152.7	0.97
6	54.1	0.74
7	96.2	0.72
8	115.5	0.71
9	64.9	0.65
10	285.0	0.45

SCALE: Linear DATE: 19-FEB-88

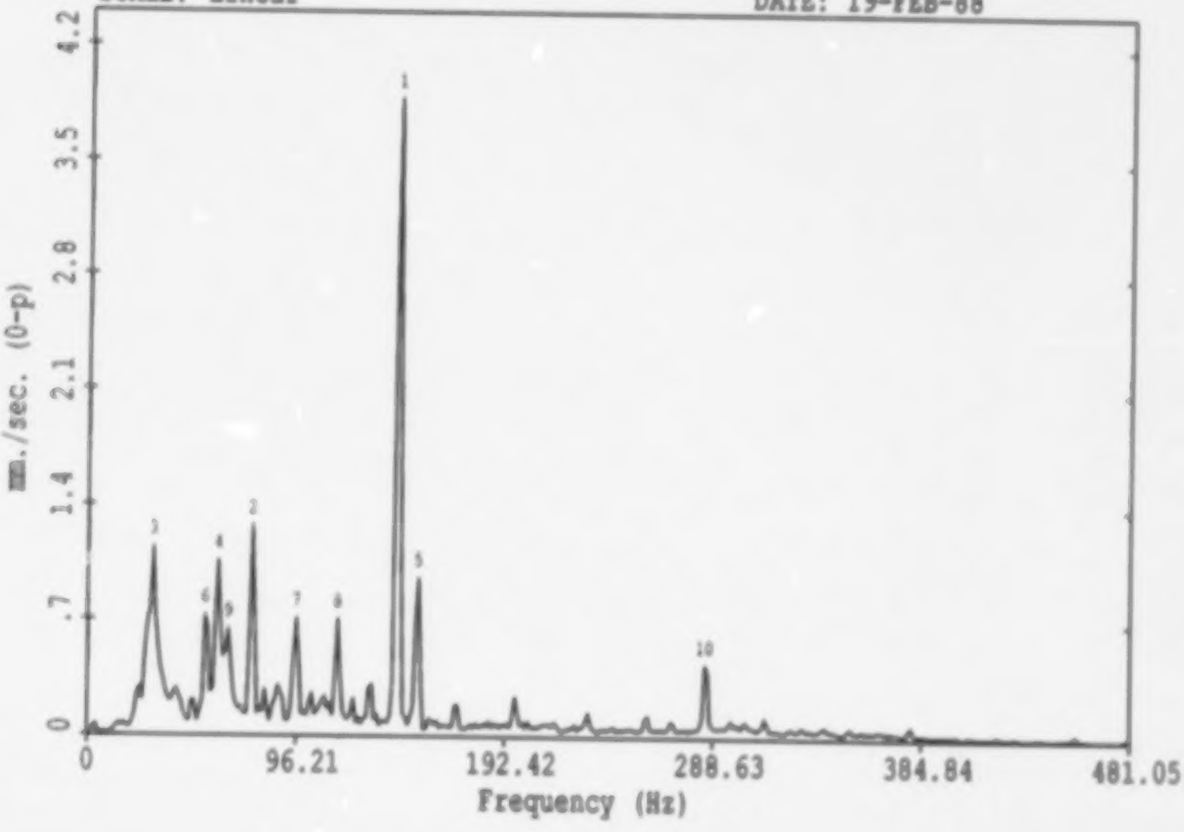


FIGURE D10

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY HORIZONTAL
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.72
2	27.7	1.70
3	60.1	1.22
4	30.1	1.20
5	153.9	0.88
6	75.8	0.81
7	55.3	0.59
8	115.5	0.57
9	33.7	0.57
10	285.0	0.54

SCALE: Linear

DATE: 19-FEB-88

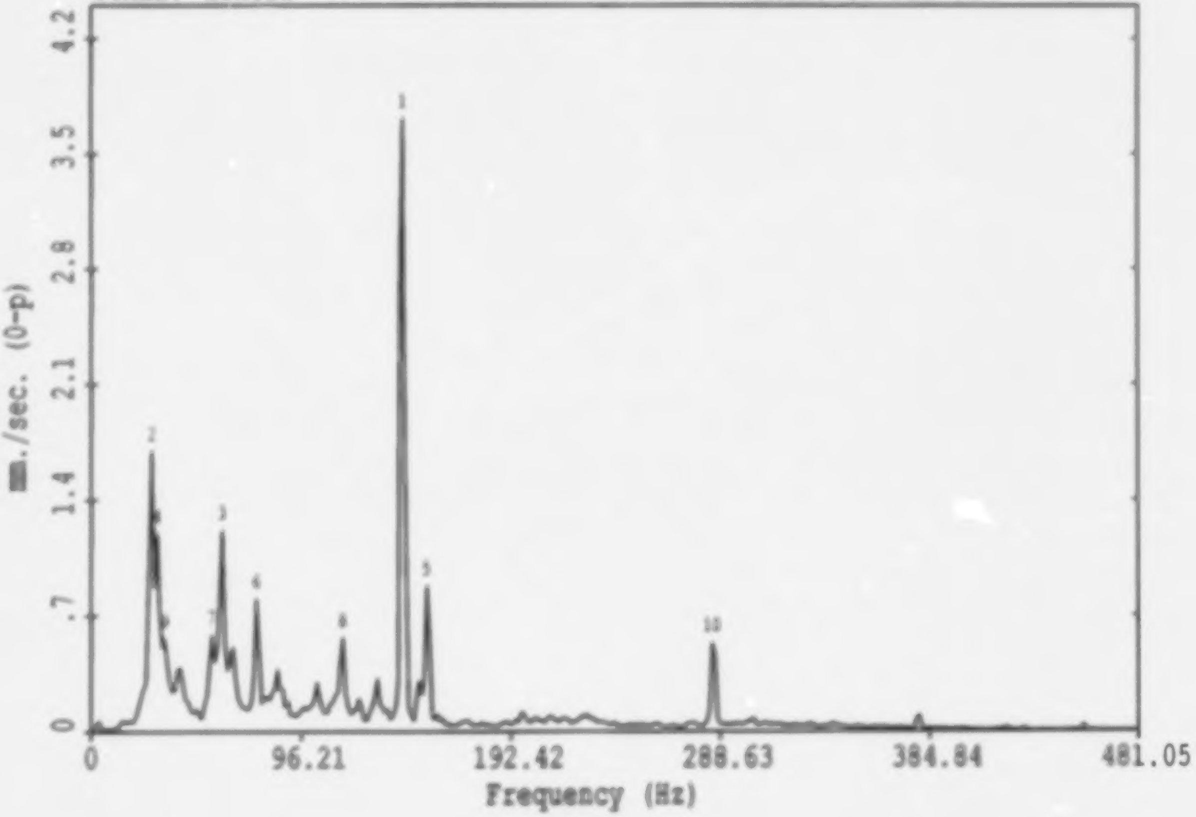


FIGURE D11

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY HORIZONTAL
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	4.13
2	27.7	2.75
3	60.1	1.42
4	56.5	0.90
5	155.1	0.77
6	75.8	0.66
7	285.0	0.56
8	64.9	0.55
9	34.9	0.51
10	85.4	0.45

SCALE: Linear

DATE: 19-FEB-88

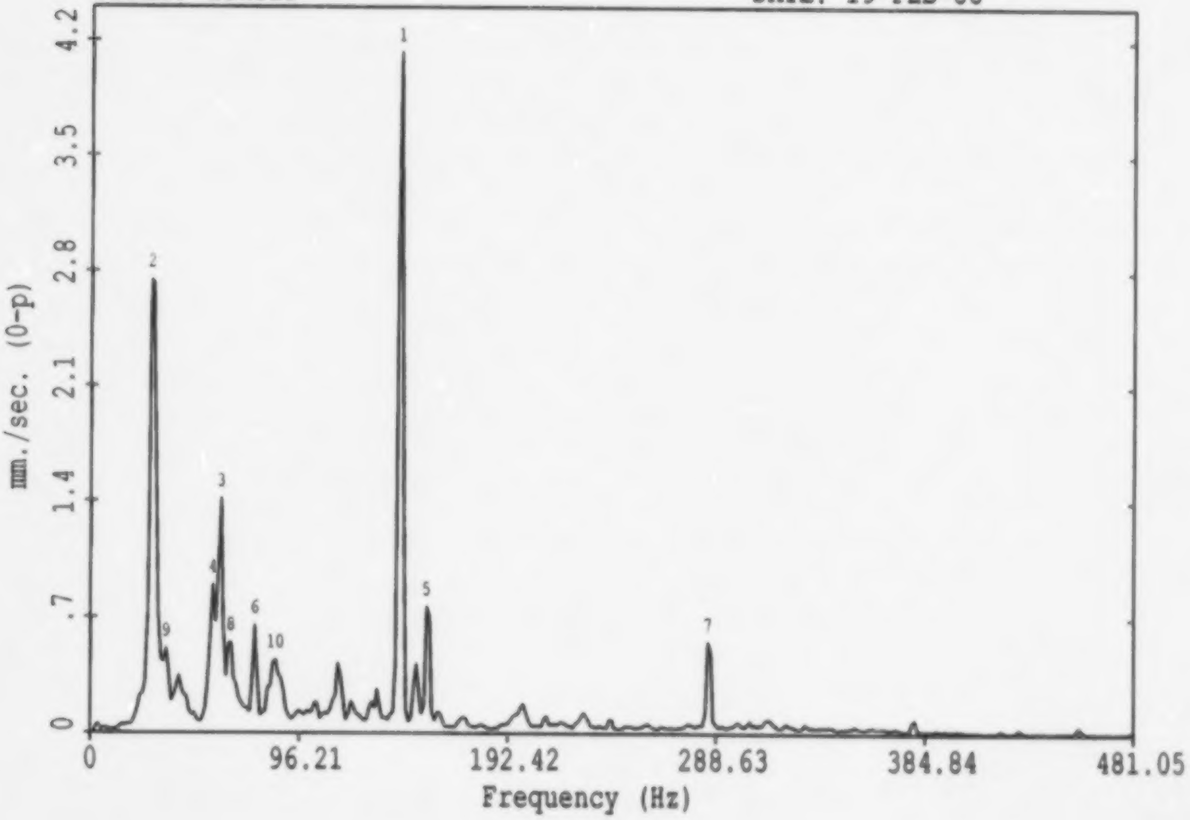


FIGURE D12

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY HORIZONTAL
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	8.76
2	60.1	5.58
3	143.1	4.45
4	75.8	1.03
5	157.5	0.97
6	150.3	0.67
7	34.9	0.54
8	285.0	0.53
9	90.2	0.46
10	22.9	0.35

SCALE: Linear DATE: 19-FEB-88

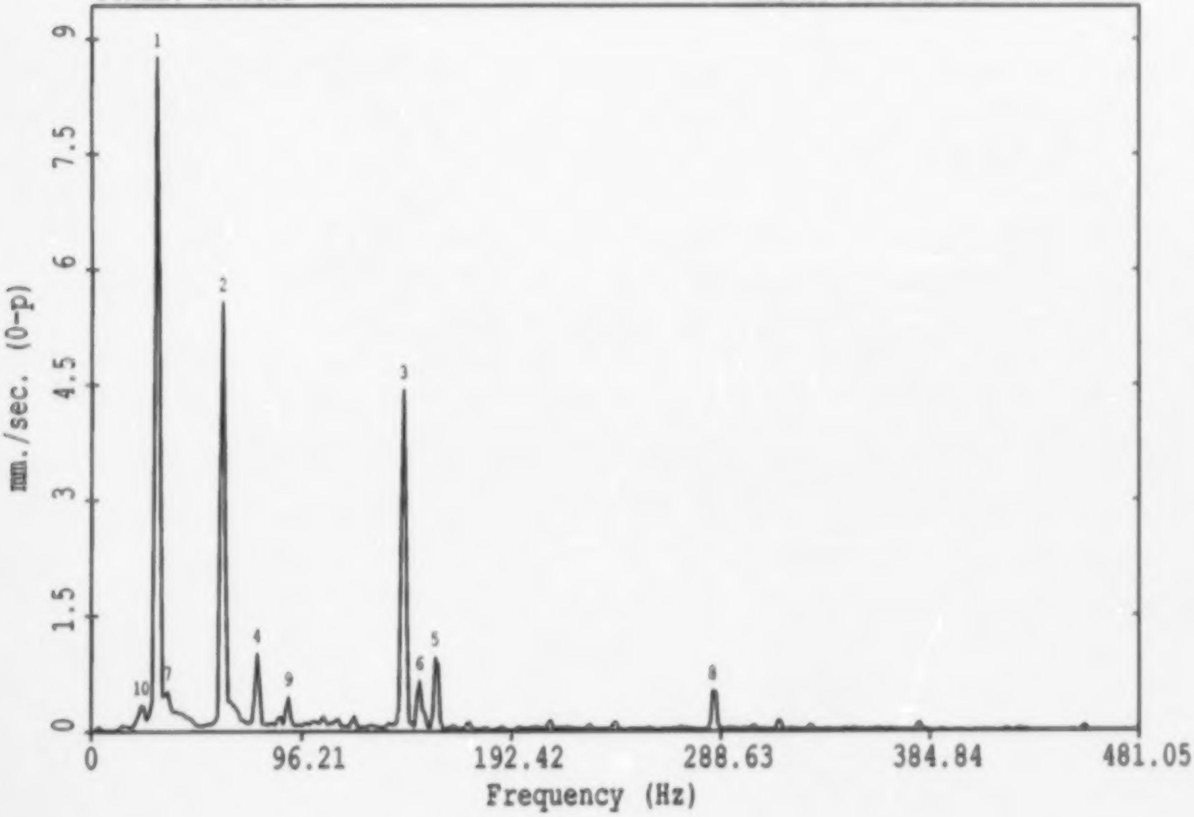


FIGURE D13

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY HORIZONTAL
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	10.15
2	143.1	5.14
3	161.2	1.25
4	75.8	1.23
5	150.3	0.97
6	90.2	0.91
7	120.3	0.71
8	60.1	0.62
9	285.0	0.42
10	24.1	0.40

SCALE: Linear

DATE: 19-FEB-88

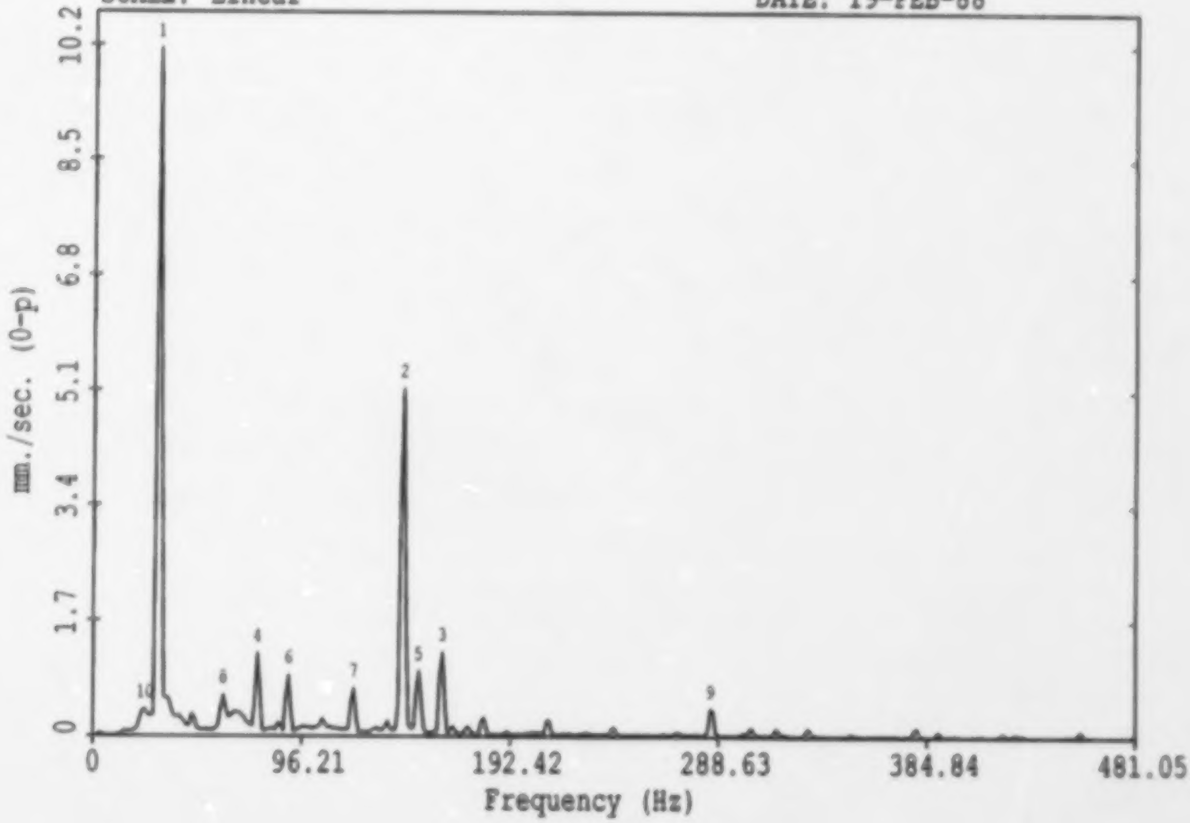


FIGURE D14

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY HORIZONTAL
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	10.67
2	143.1	5.41
3	162.4	1.55
4	75.8	1.29
5	60.1	1.24
6	98.6	1.11
7	150.3	0.88
8	33.7	0.79
9	120.3	0.40
10	285.0	0.40

SCALE: Linear

DATE: 19-FEB-88

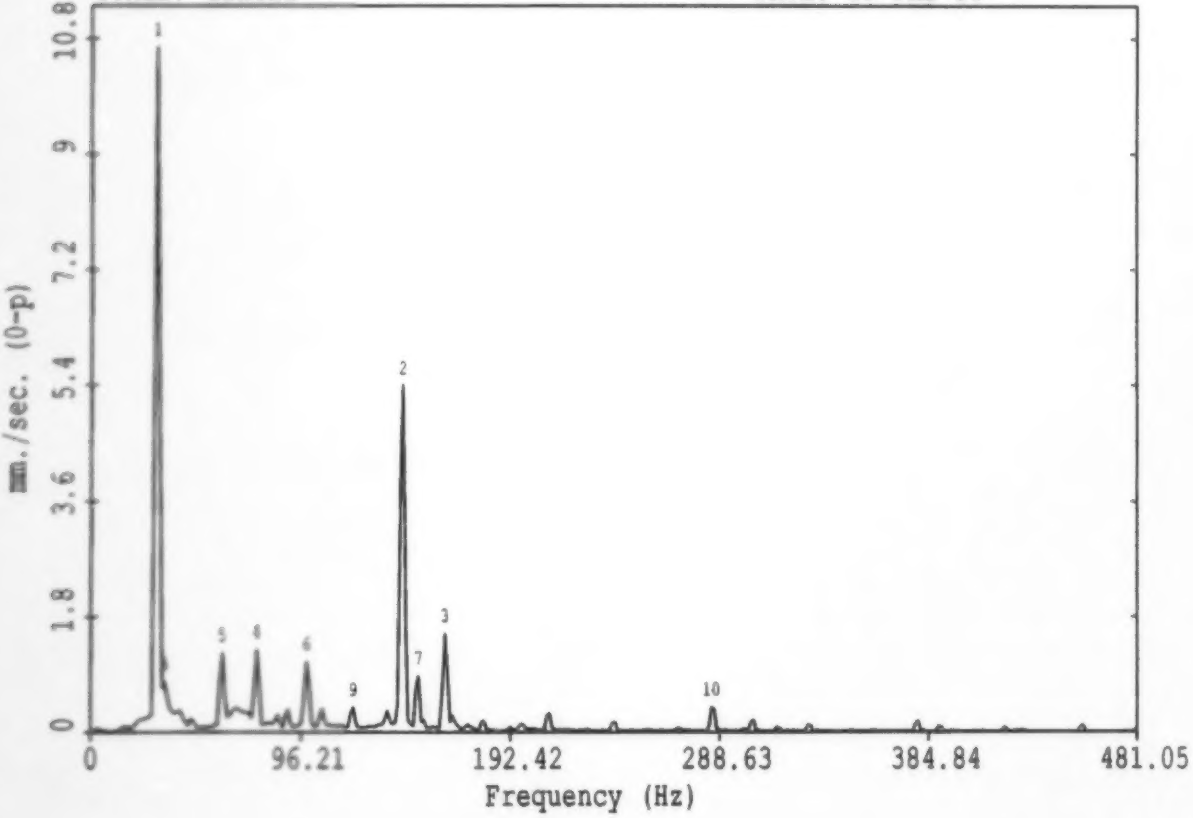


FIGURE D15

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY HORIZONTAL
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	10.50
2	143.1	5.42
3	75.8	1.94
4	60.1	1.93
5	167.2	1.83
6	150.3	0.92
7	120.3	0.73
8	37.3	0.63
9	34.9	0.61
10	210.5	0.42

SCALE: Linear DATE: 19-FEB-88

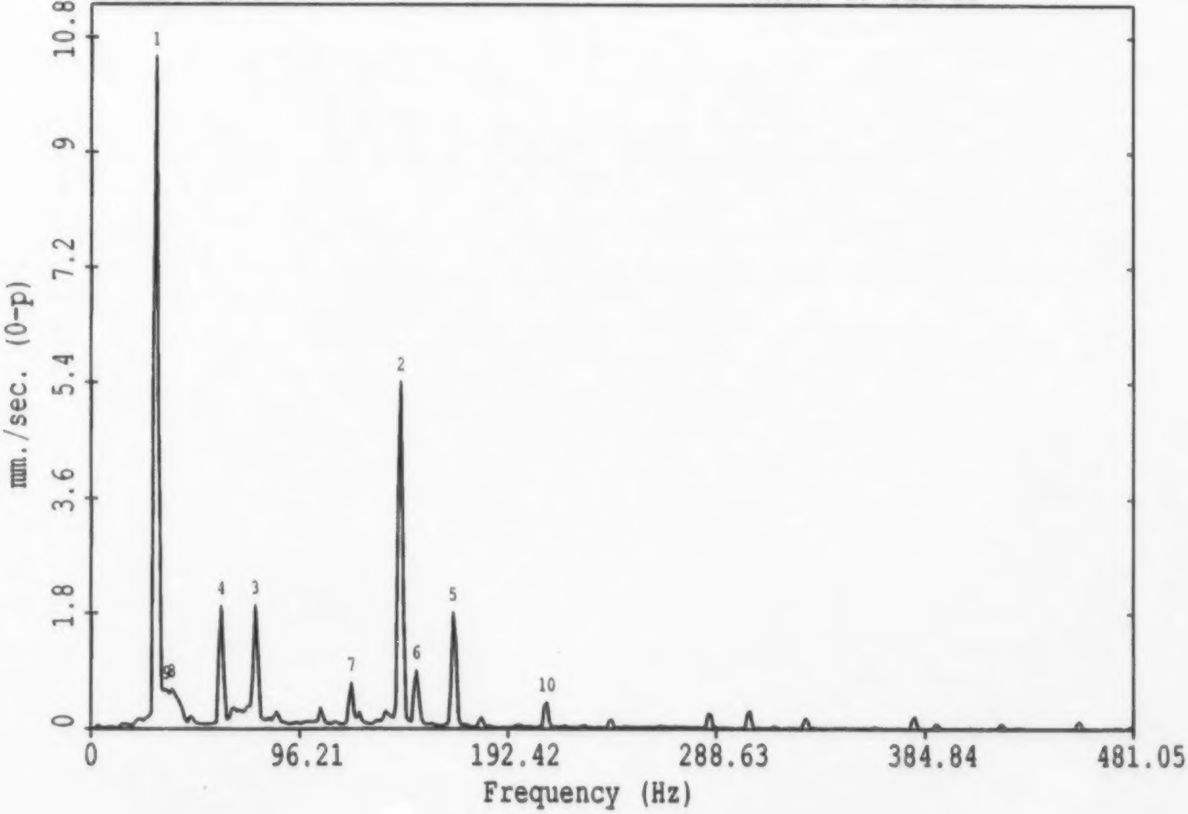


FIGURE D16

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	95.0	1.36
2	143.1	1.16
3	147.9	1.06
4	71.0	0.85
5	119.1	0.54
6	286.2	0.47
7	48.1	0.46
8	16.8	0.45
9	75.8	0.27
10	24.1	0.21

SCALE: Linear DATE: 19-FEB-88

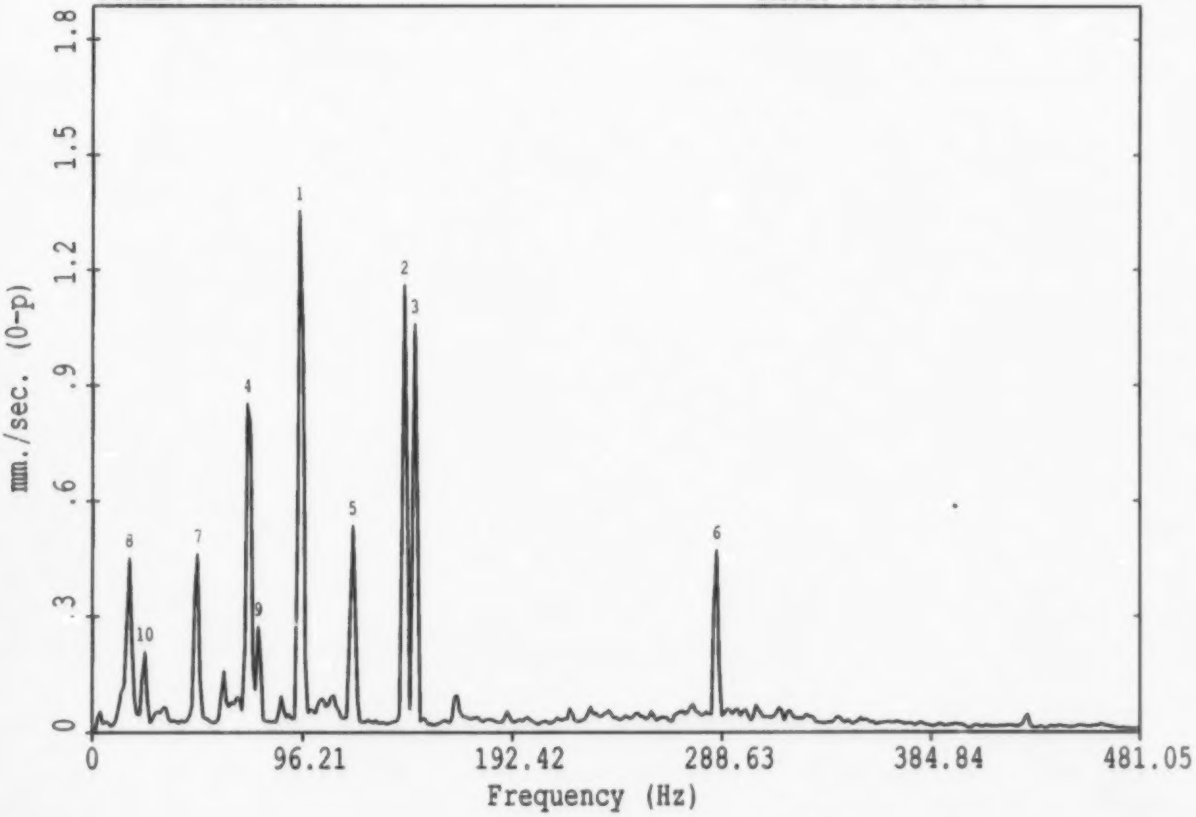


FIGURE D17

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 1 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	96.2	3.93
2	143.1	1.35
3	152.7	0.75
4	16.8	0.57
5	285.0	0.54
6	48.1	0.53
7	54.1	0.31
8	13.2	0.23
9	75.8	0.20
10	60.1	0.20

SCALE: Linear DATE: 19-FEB-88

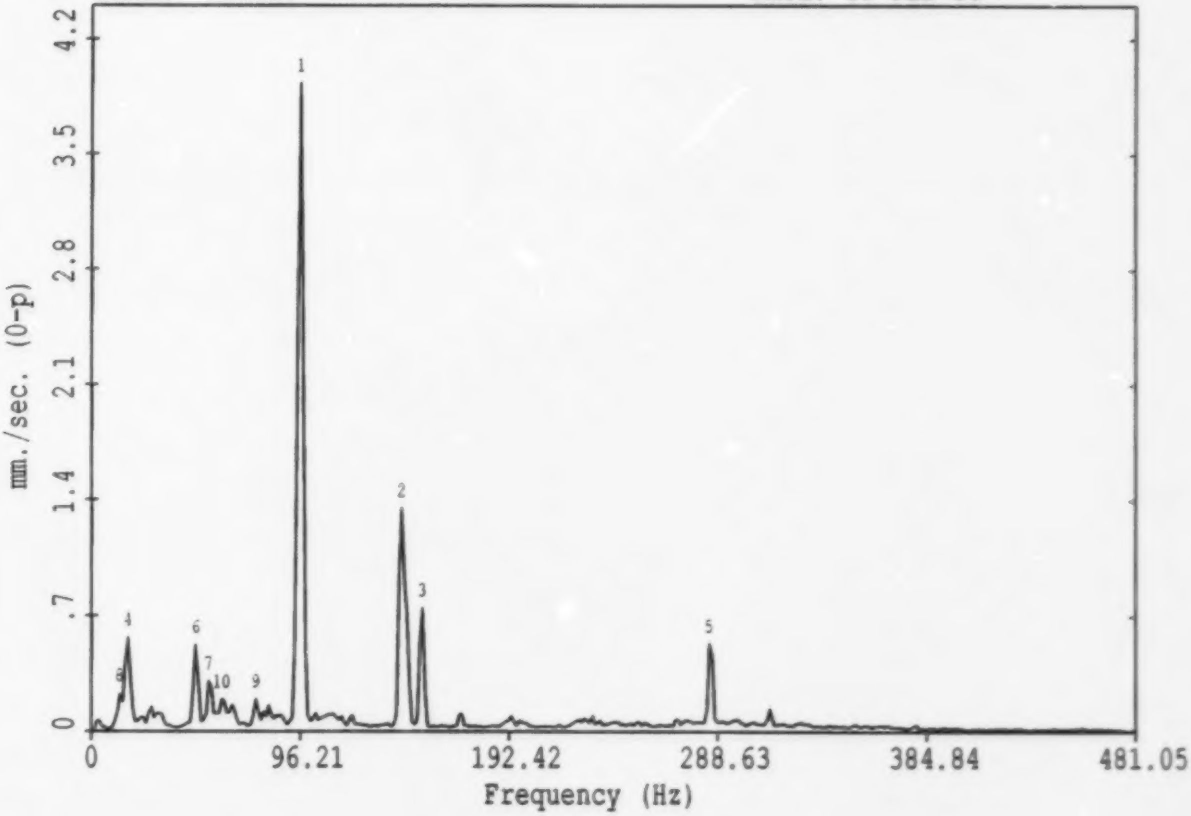


FIGURE D18

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	1.48
2	115.5	1.31
3	113.0	1.28
4	56.5	0.55
5	153.9	0.51
6	16.8	0.50
7	285.0	0.33
8	168.4	0.31
9	173.2	0.28
10	27.7	0.25

SCALE: Linear

DATE: 19-FEB-88

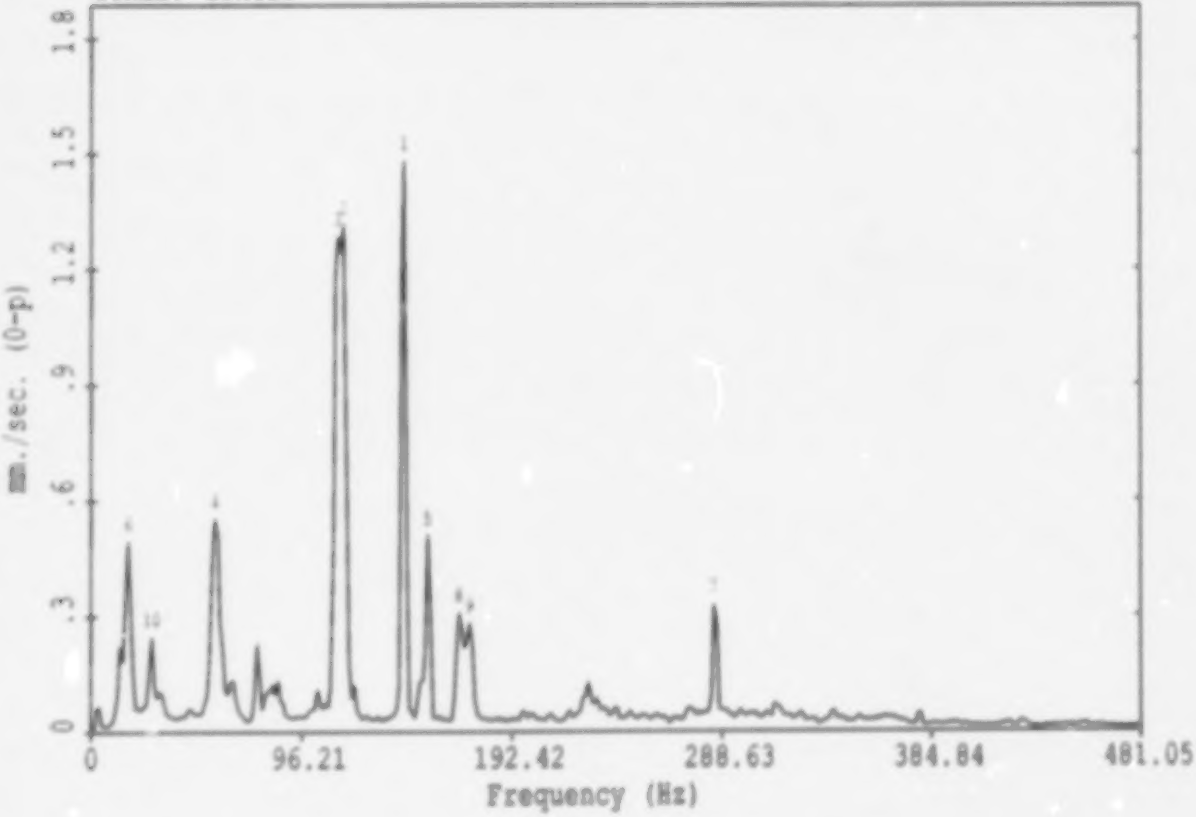


FIGURE D19

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	128.7	2.04
2	143.1	1.66
3	64.9	0.94
4	155.1	0.43
5	193.6	0.43
6	16.8	0.32
7	56.5	0.31
8	27.7	0.26
9	285.0	0.21
10	75.8	0.20

SCALE: Linear DATE: 19-FEB-88

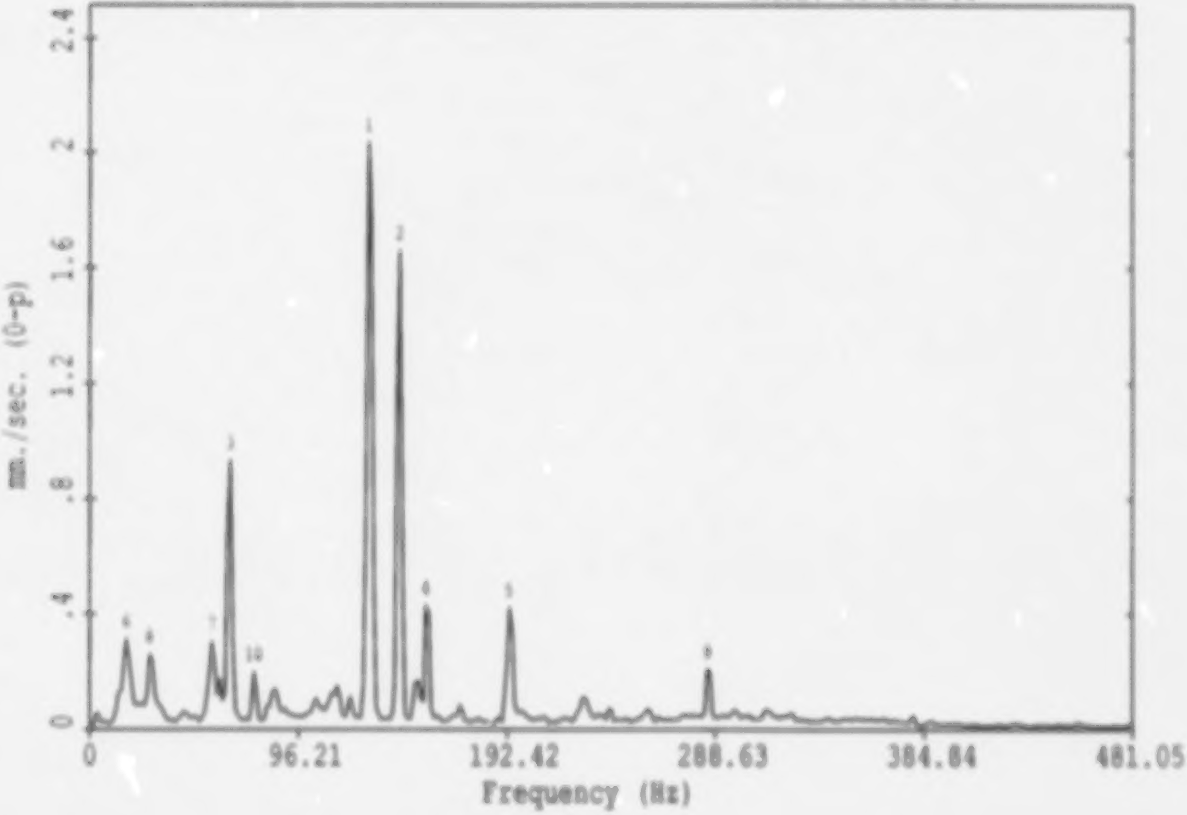


FIGURE D20

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	75.8	1.83
2	143.1	1.77
3	152.7	1.62
4	60.1	1.02
5	30.1	0.71
6	157.5	0.39
7	16.8	0.31
8	228.5	0.29
9	105.8	0.23
10	90.2	0.20

SCALE: Linear

DATE: 19-FEB-88

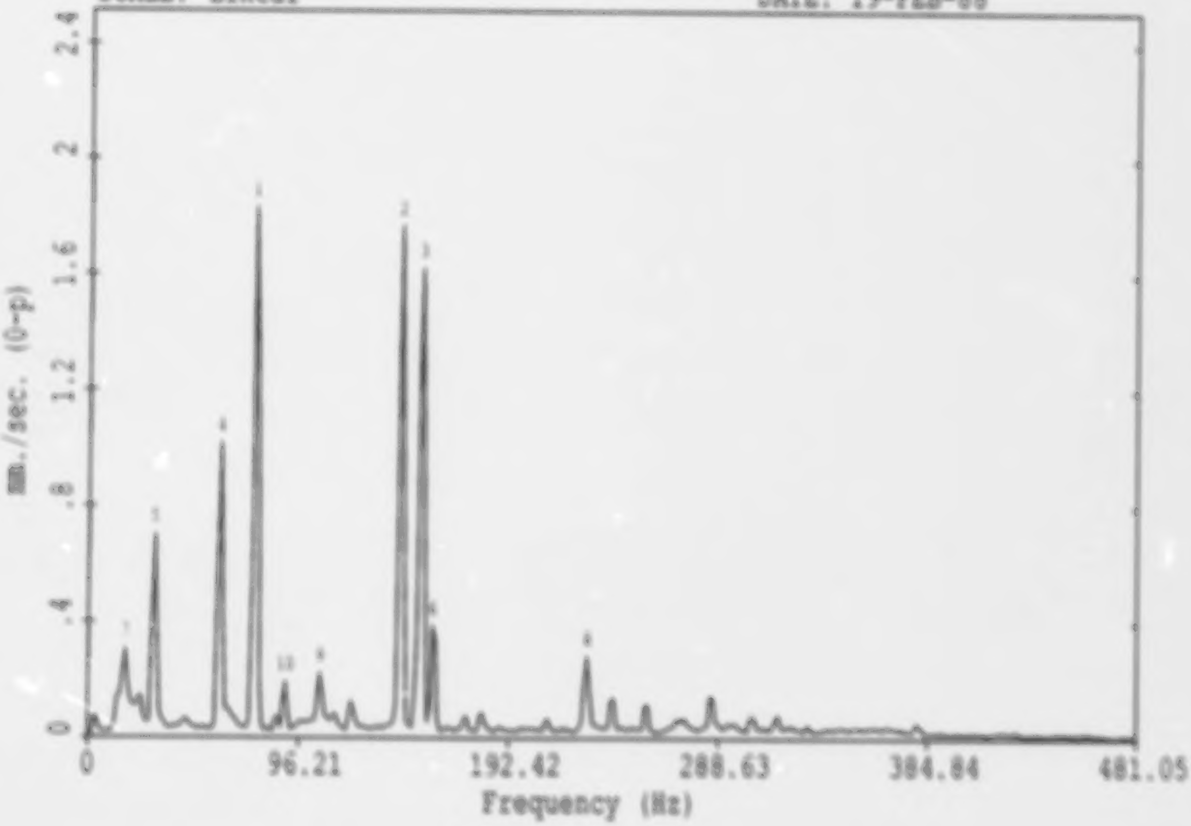


FIGURE D21

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	90.2	4.14
2	143.1	1.68
3	180.4	1.04
4	30.1	1.00
5	60.1	0.53
6	161.2	0.47
7	75.8	0.43
8	151.5	0.40
9	285.0	0.30
10	105.8	0.25

SCALE: Linear

DATE: 19-FEB-88

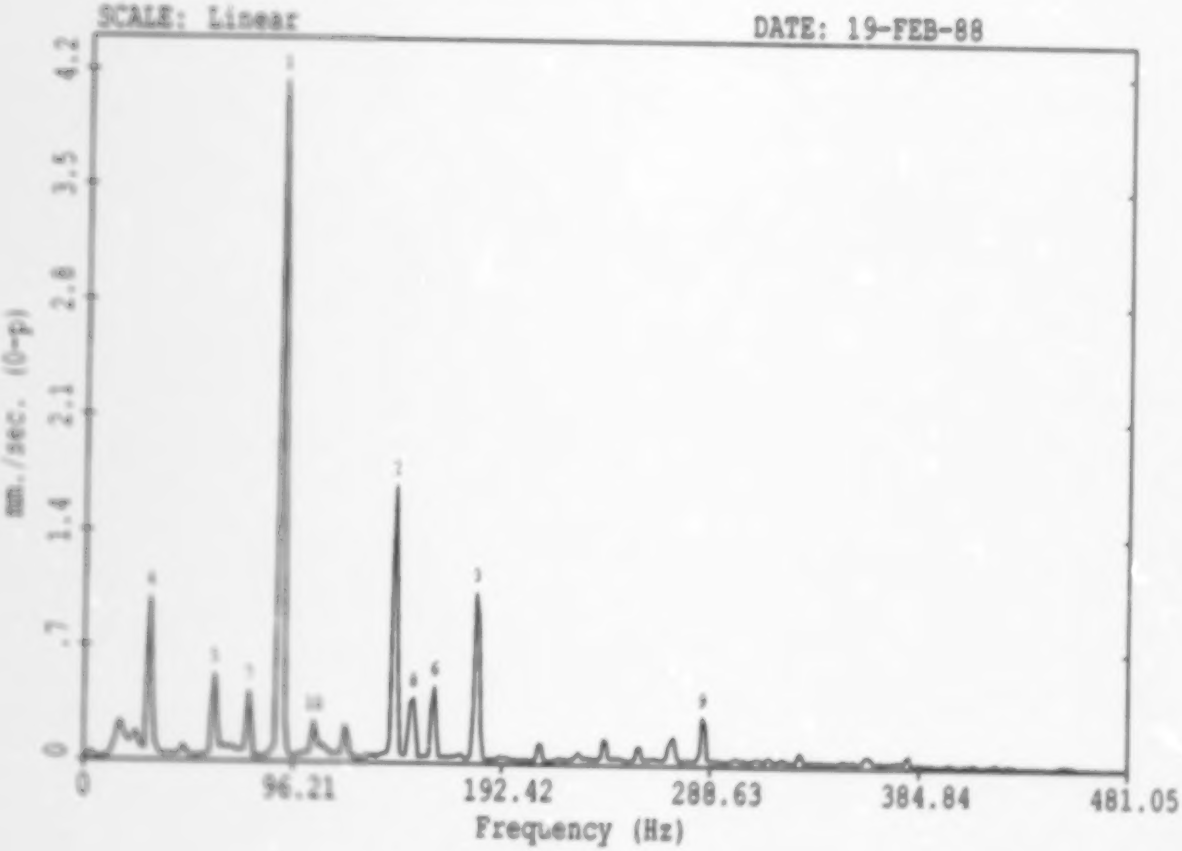


FIGURE D22

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	98.6	5.35
2	143.1	1.50
3	30.1	1.08
4	197.2	0.65
5	75.8	0.57
6	162.4	0.50
7	151.5	0.38
8	285.0	0.32
9	128.7	0.29
10	149.1	0.25

SCALE: Linear

DATE: 19-FEB-88

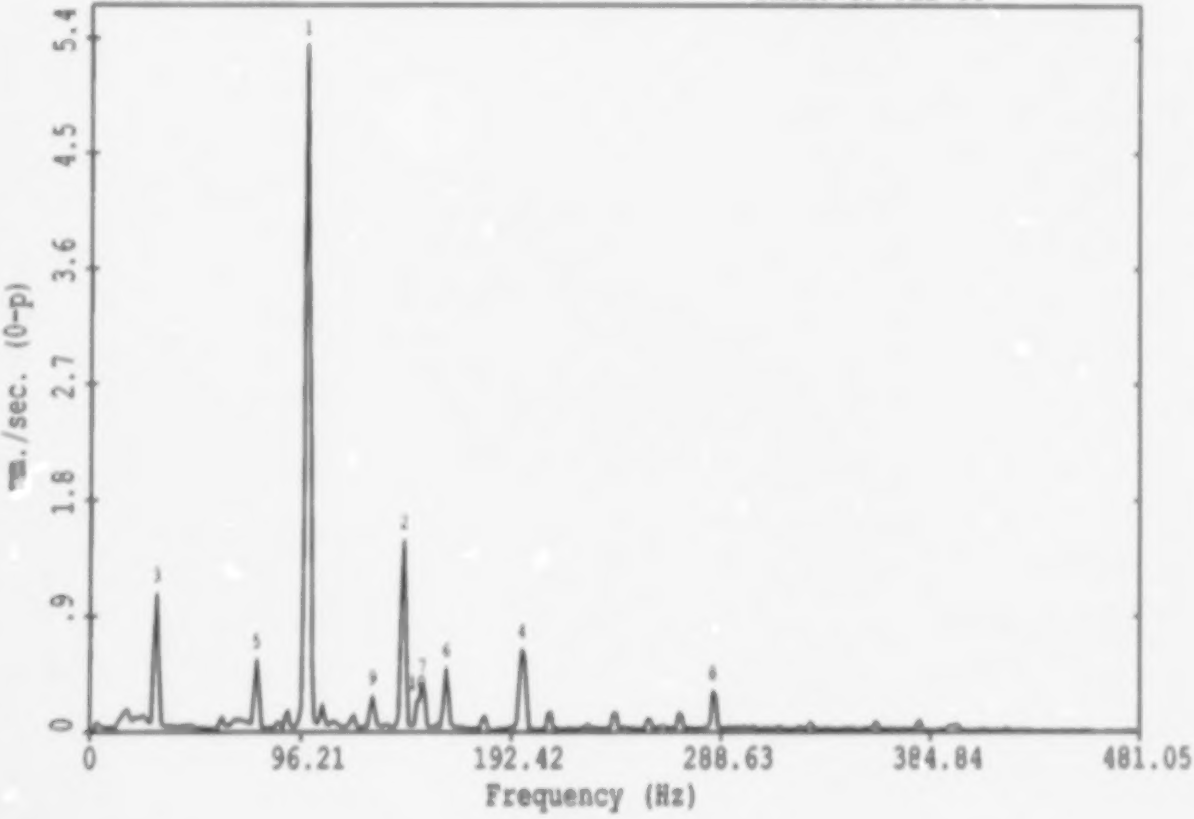


FIGURE D23

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 CASING VELOCITY AXIAL
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	123.9	3.47
2	143.1	1.16
3	30.1	1.02
4	75.8	0.90
5	167.2	0.78
6	151.5	0.57
7	60.1	0.47
8	247.7	0.42
9	285.0	0.39
10	210.5	0.22

SCALE: Linear

DATE: 19-FEB-88

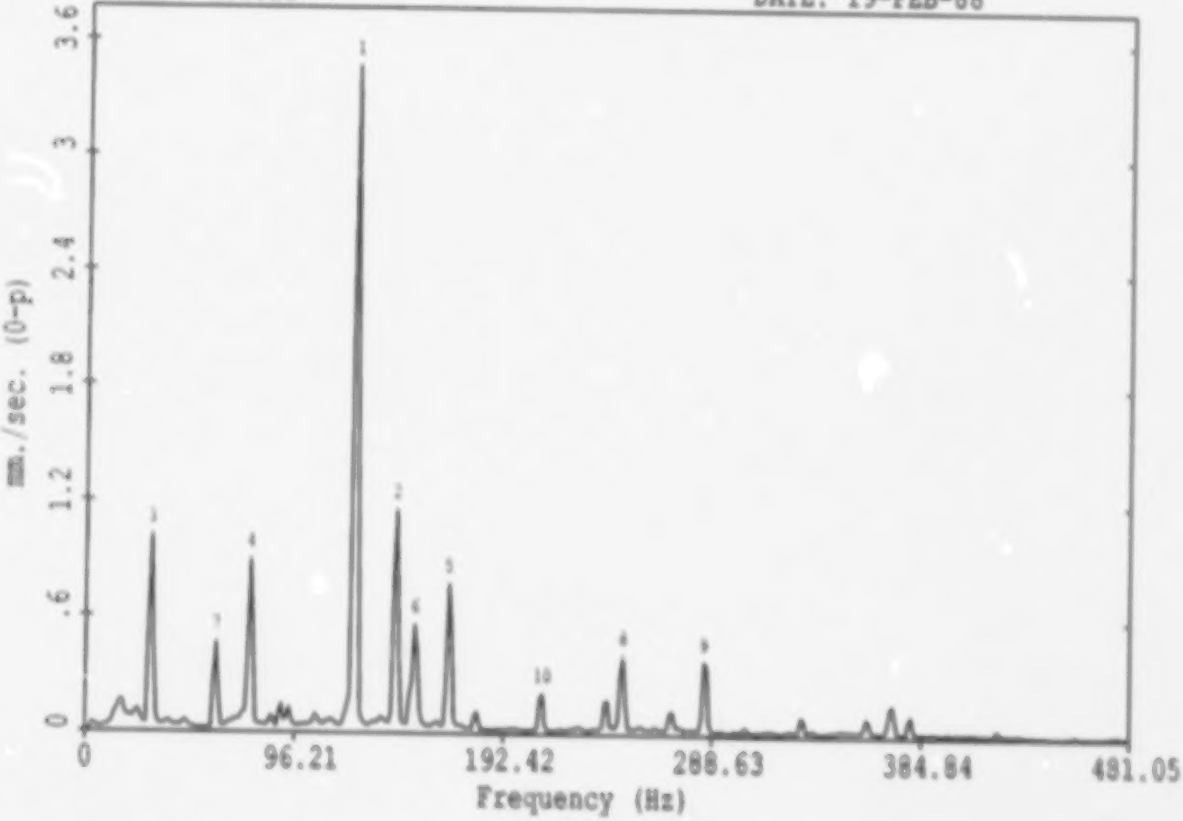


FIGURE D24

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	4.30
2	147.9	1.20
3	75.8	0.62
4	429.3	0.55
5	60.1	0.41
6	286.2	0.40
7	30.1	0.26
8	218.9	0.26
9	32.5	0.25
10	42.1	0.21

SCALE: Linear DATE: 19-FEB-88

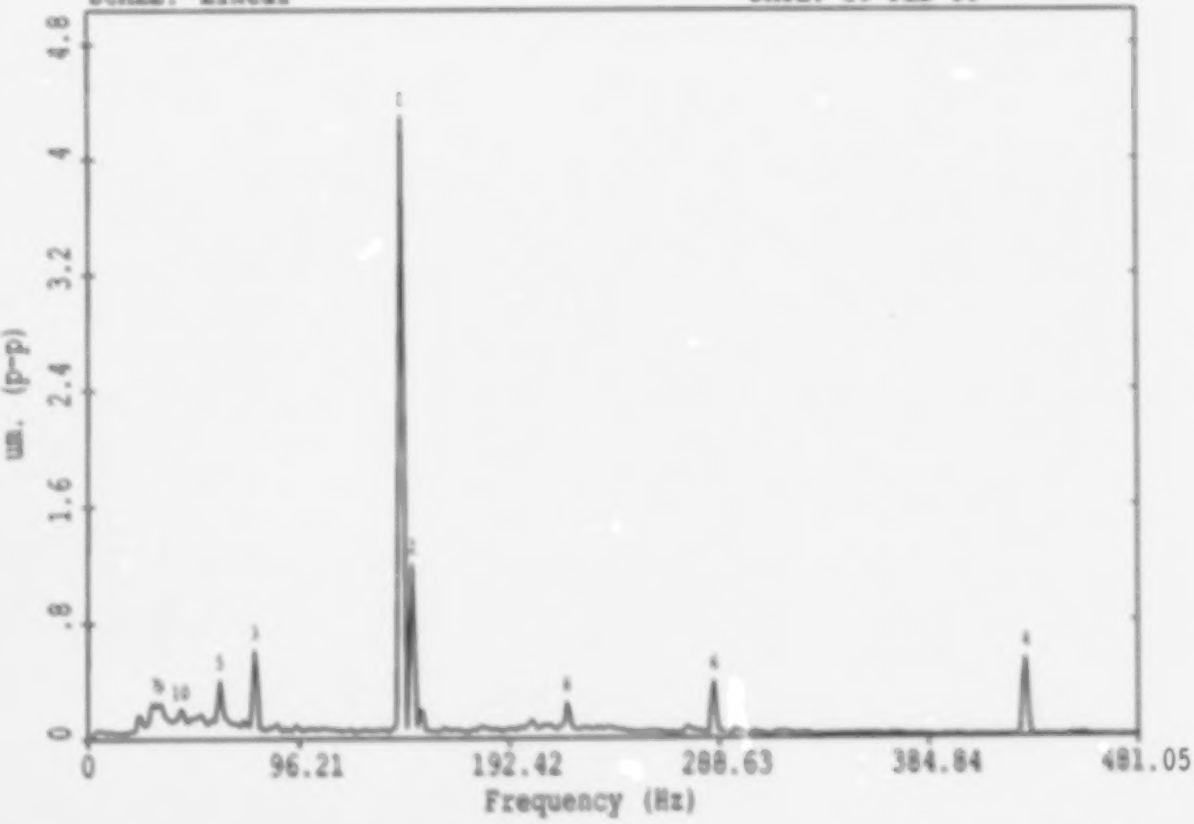


FIGURE D25

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	4.00
2	152.7	2.03
3	75.8	1.33
4	54.1	1.03
5	27.7	0.52
6	428.1	0.50
7	30.1	0.48
8	57.7	0.36
9	97.4	0.35
10	60.1	0.35
		0.35

SCALE: Linear

DATE: 19-FEB-88

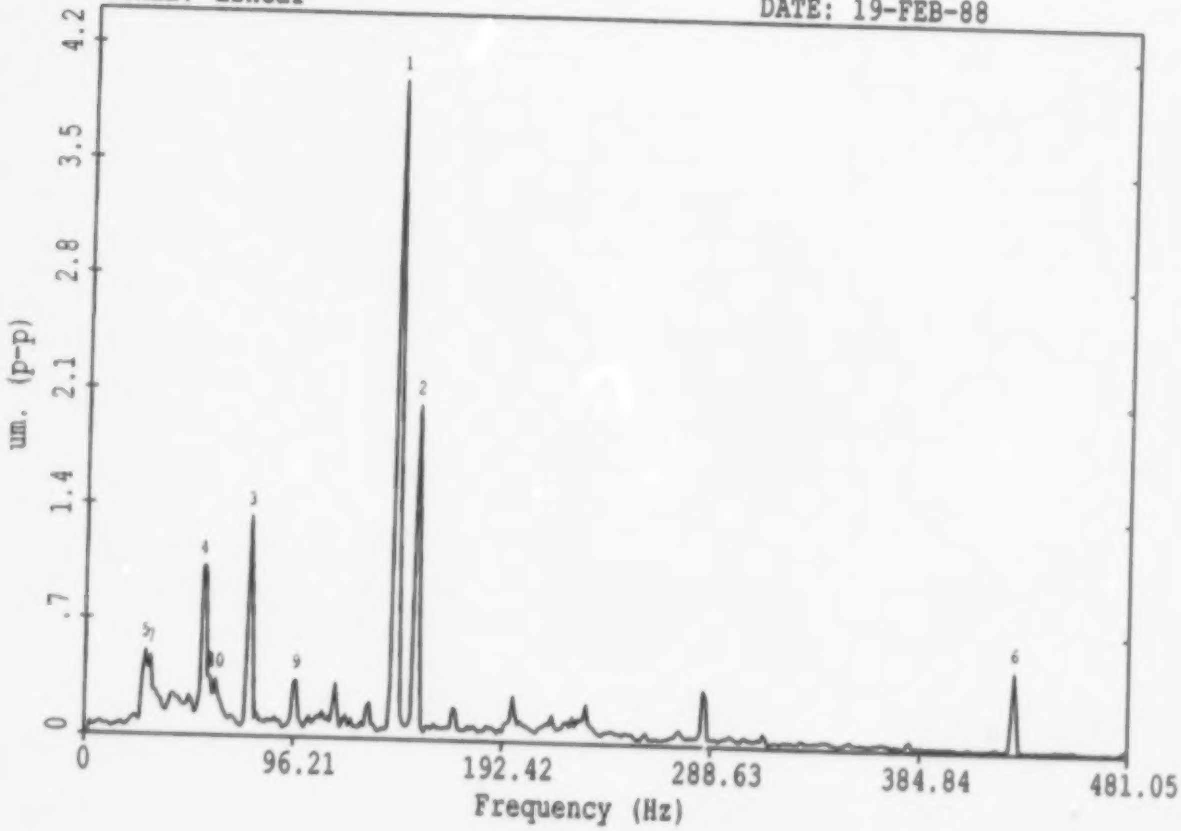


FIGURE D26

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.83
2	153.9	1.45
3	75.8	1.04
4	55.3	0.94
5	27.7	0.70
6	428.1	0.49
7	285.0	0.44
8	60.1	0.40
9	31.3	0.39
10	42.1	0.35

SCALE: Linear

DATE: 19-FEB-88

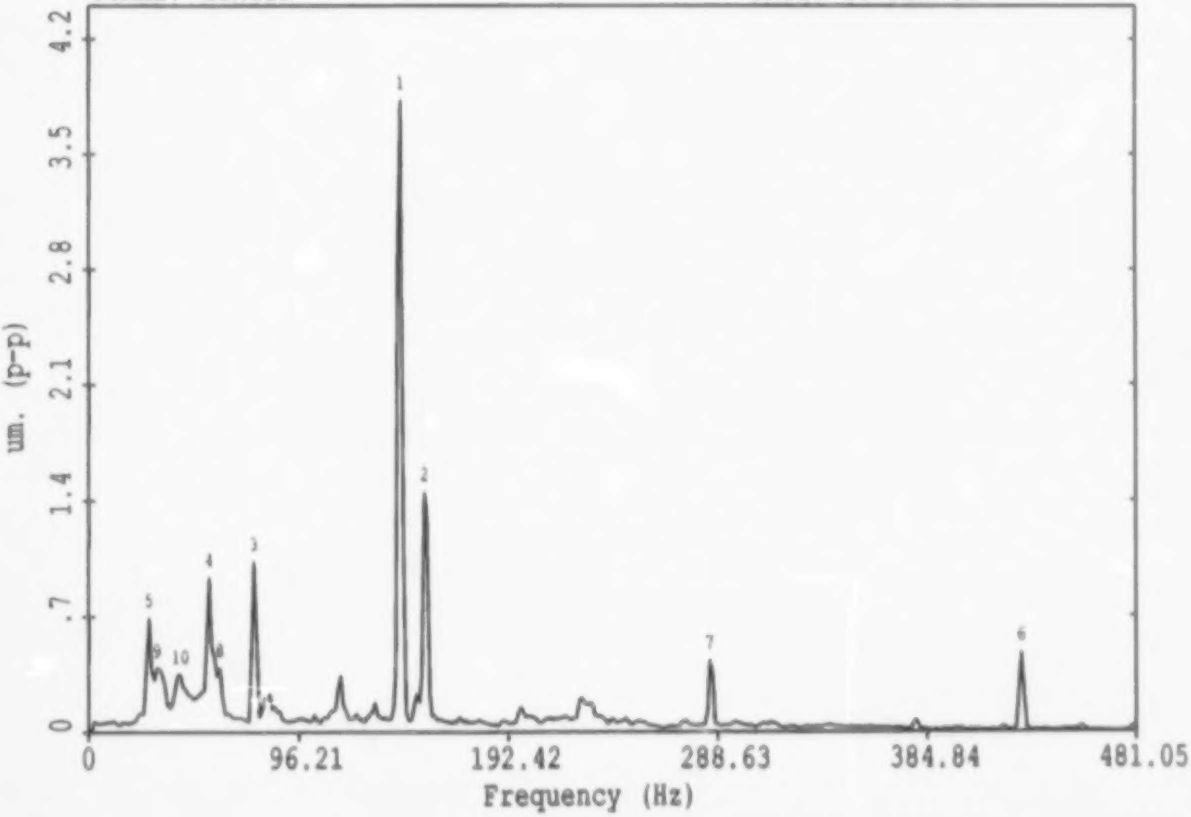


FIGURE D27

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.47
2	156.3	1.62
3	56.5	1.36
4	27.7	1.16
5	75.8	1.02
6	60.1	0.52
7	428.1	0.48
8	285.0	0.45
9	42.1	0.44
10	2.4	0.43

SCALE: Linear

DATE: 19-FEB-88

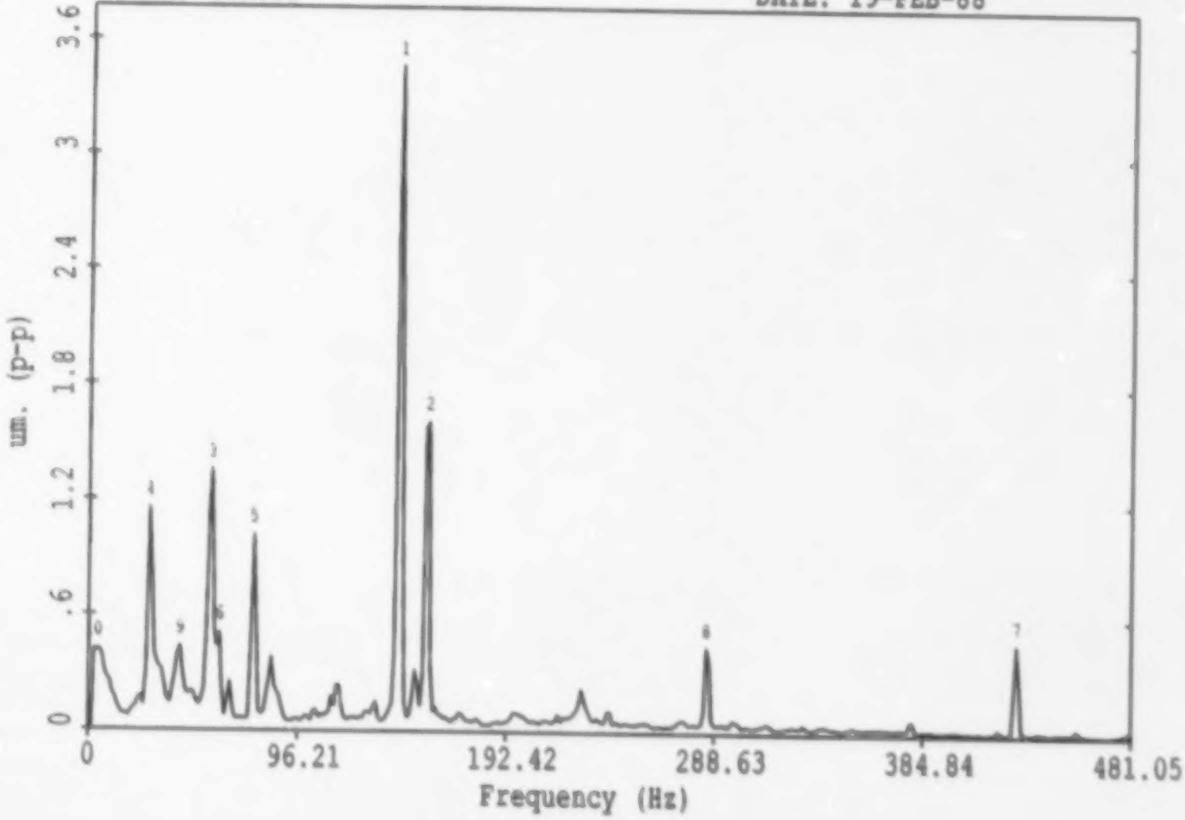


FIGURE D28

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	4.61
2	143.1	3.13
3	60.1	1.35
4	158.7	1.32
5	2.4	1.11
6	75.8	1.05
7	150.3	0.55
8	428.1	0.48
9	40.9	0.41
10	285.0	0.38

SCALE: Linear DATE: 19-FEB-88

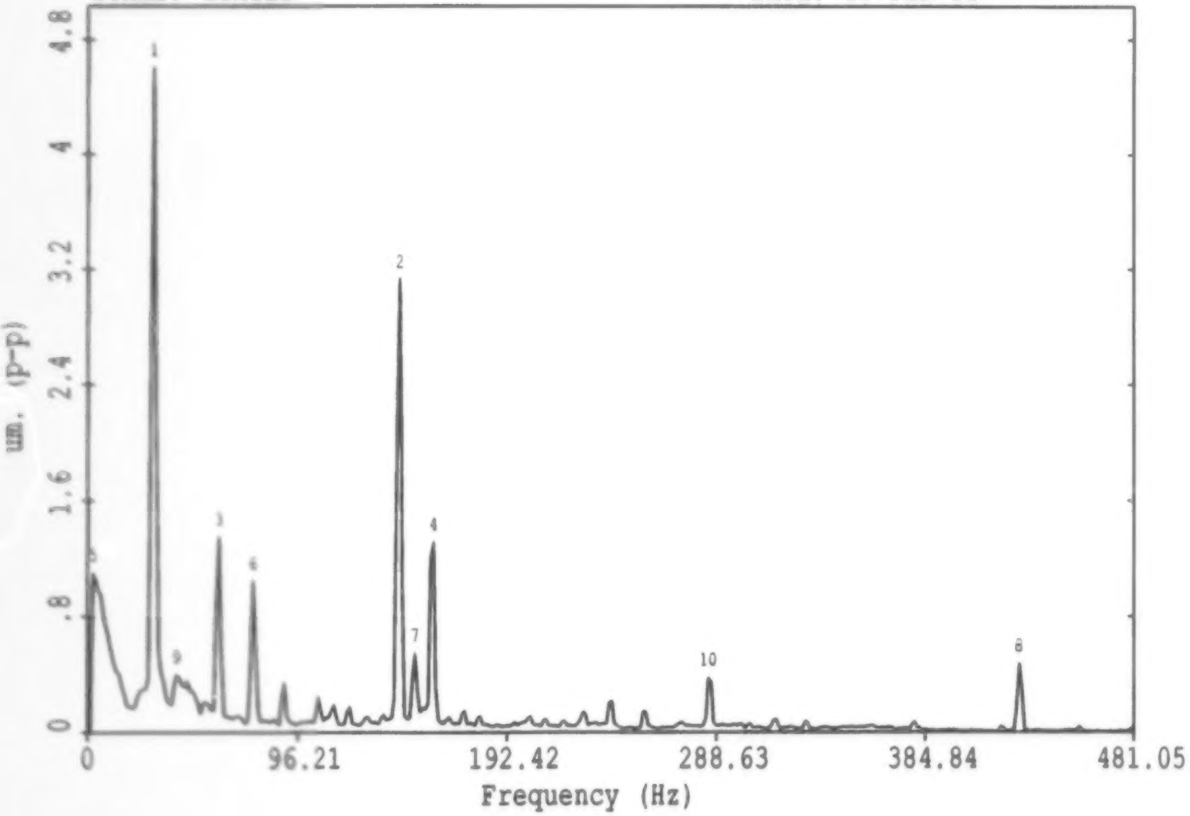


FIGURE D29

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	5.60
2	143.1	3.12
3	4.8	1.99
4	161.2	1.80
5	9.6	1.24
6	60.1	1.15
7	75.8	1.08
8	45.7	0.76
9	14.4	0.70
10	150.3	0.67

SCALE: Linear

DATE: 19-FEB-88

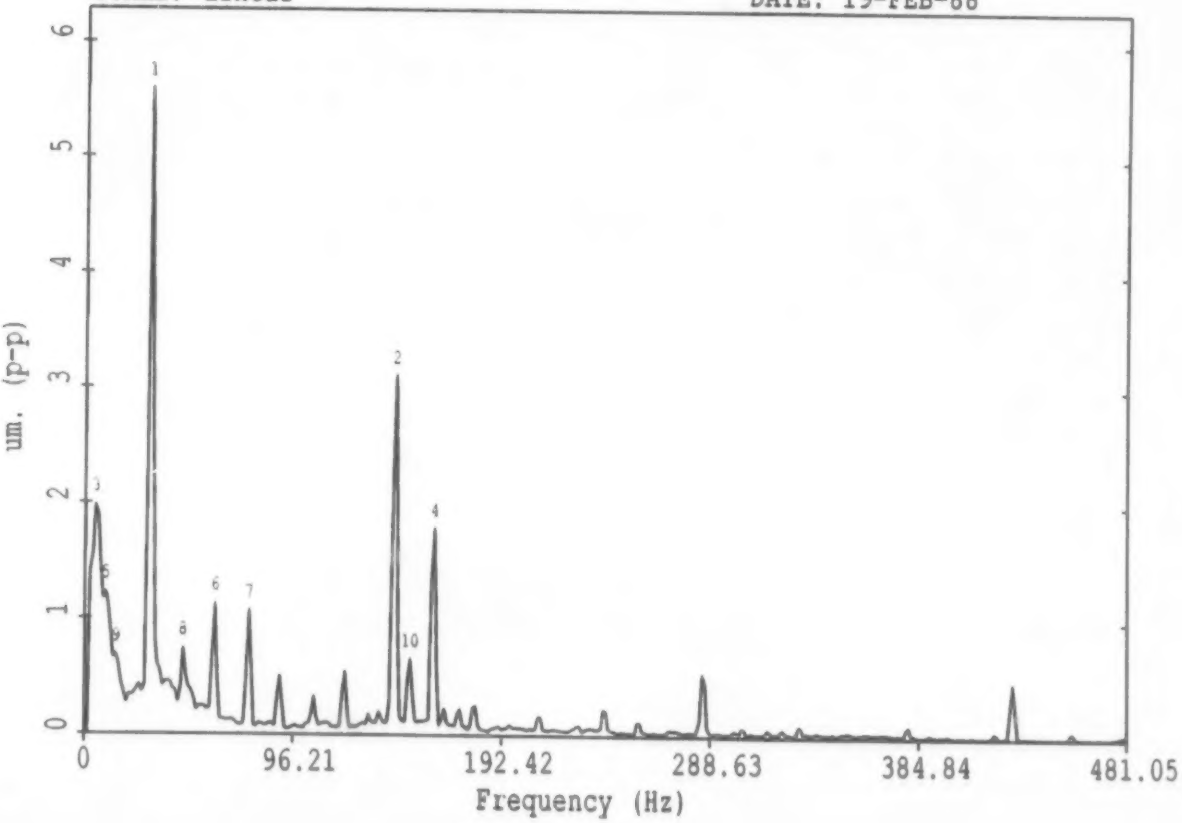


FIGURE D30

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	6.10
2	143.1	3.44
3	162.4	1.75
4	6.0	1.29
5	3.6	1.19
6	75.8	0.99
7	9.6	0.95
8	150.3	0.74
9	45.7	0.66
10	285.0	0.58

SCALE: Linear DATE: 19-FEB-88

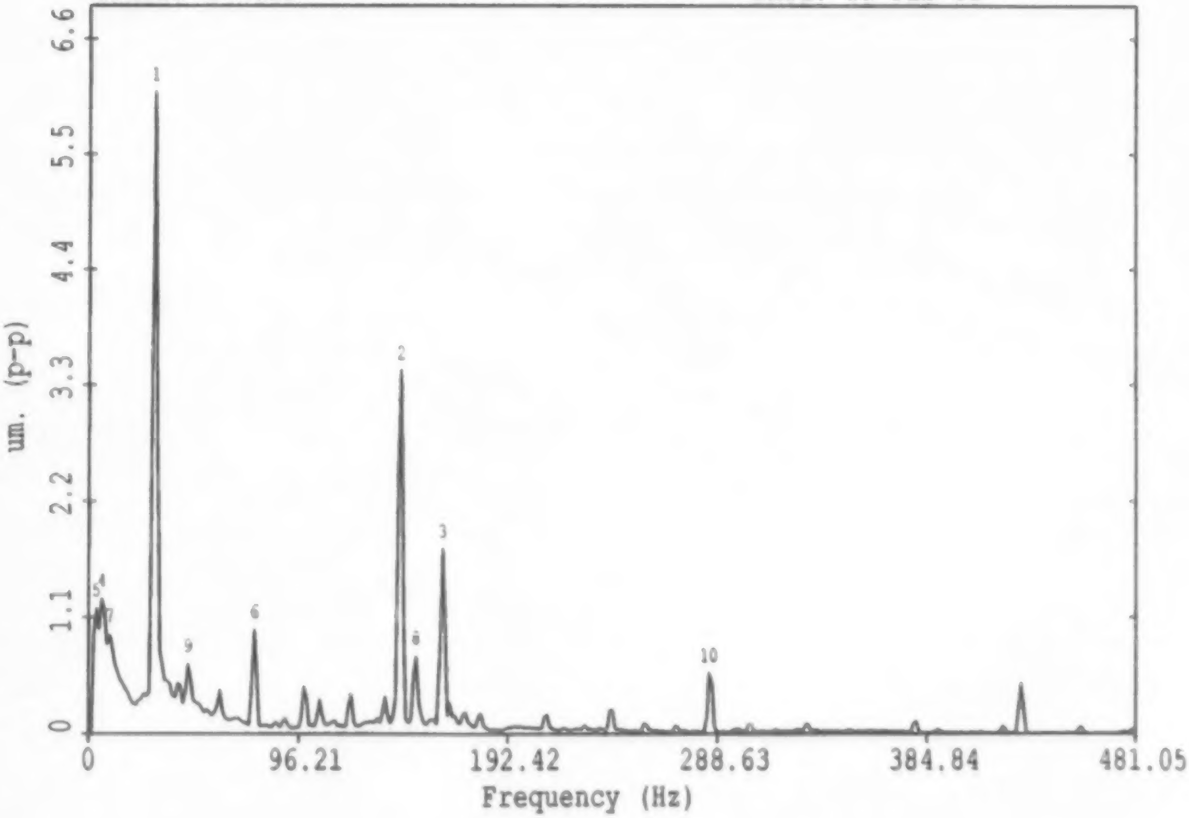


FIGURE D31

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	6.32
2	143.1	4.05
3	167.2	1.62
4	6.0	1.03
5	3.6	1.01
6	75.8	0.85
7	13.2	0.73
8	39.7	0.68
9	150.3	0.66
10	60.1	0.62

SCALE: Linear

DATE: 19-FEB-88

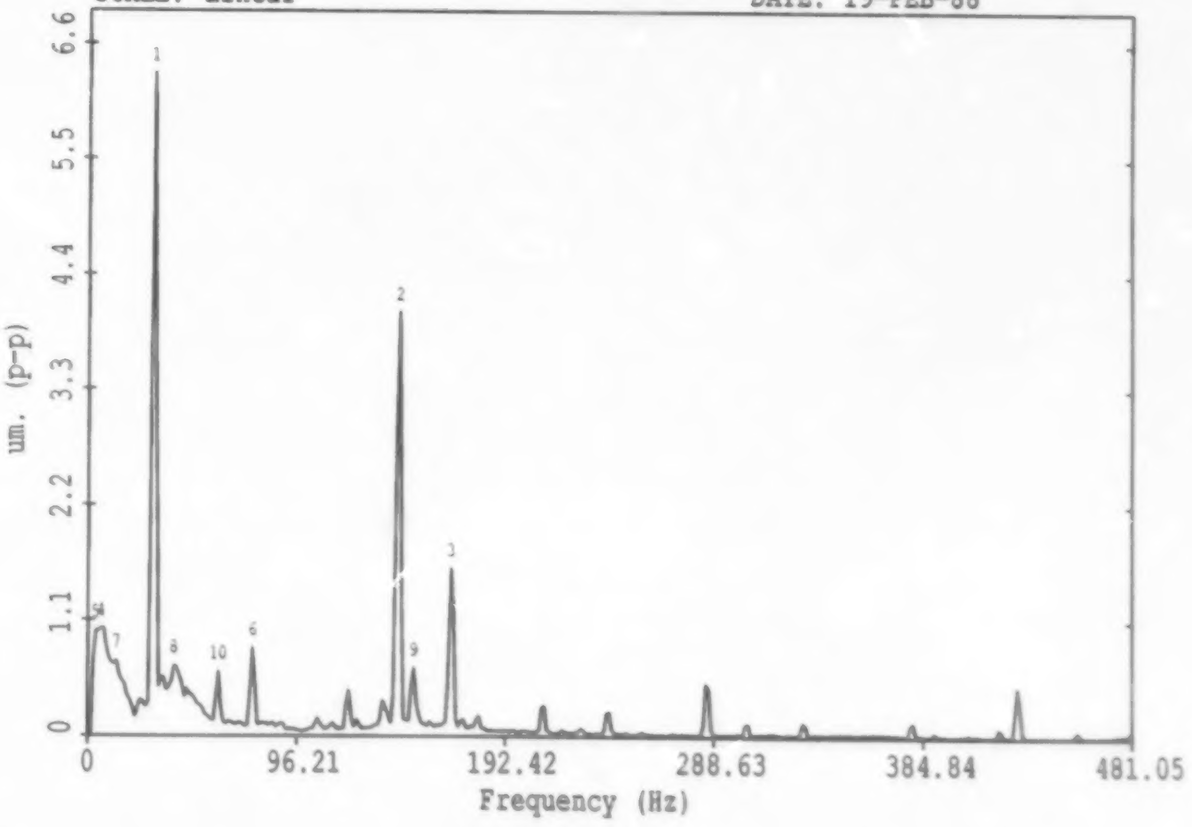


FIGURE D32

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	4.21
2	147.9	2.95
3	286.2	0.77
4	60.1	0.48
5	429.3	0.40
6	33.7	0.27
7	75.8	0.25
8	218.9	0.19
9	67.3	0.19
10	22.9	0.17

SCALE: Linear DATE: 19-FEB-88

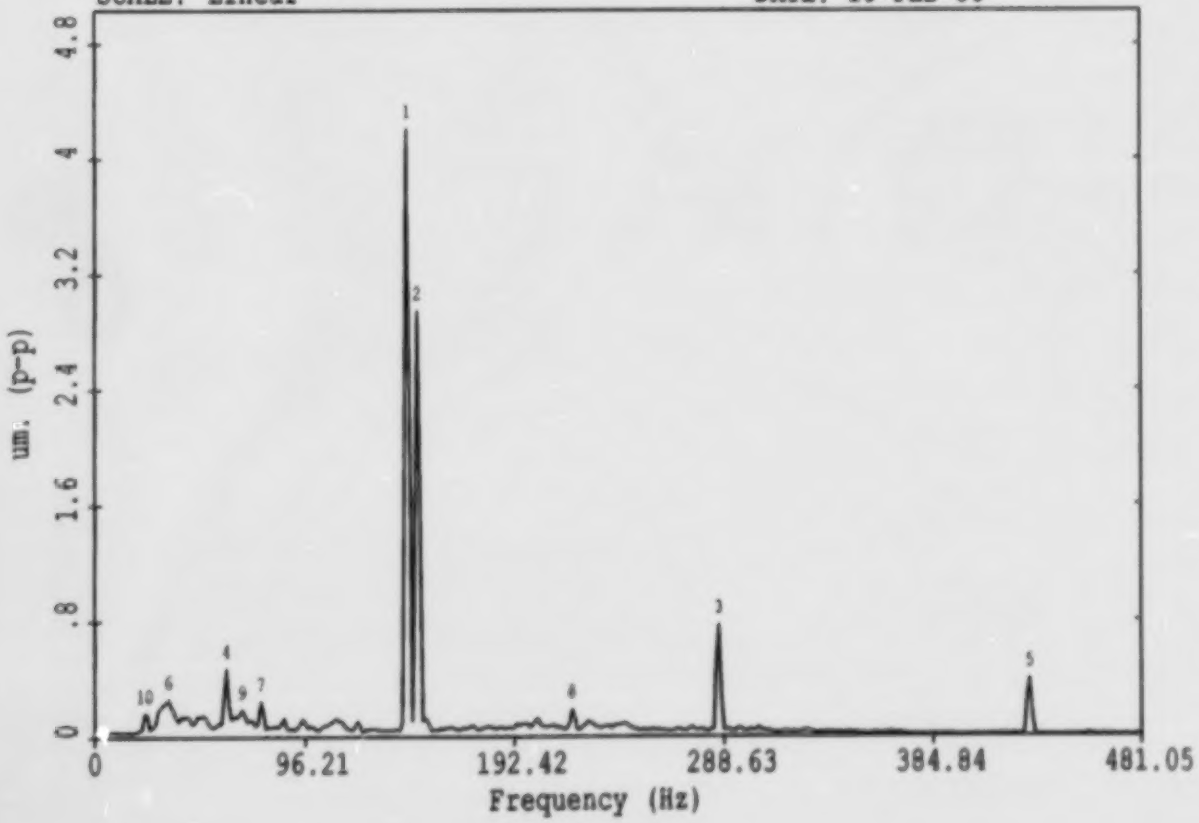


FIGURE D33

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.91
2	152.7	1.63
3	75.8	0.72
4	285.0	0.64
5	428.1	0.52
6	27.7	0.49
7	30.1	0.47
8	55.3	0.42
9	103.4	0.37
10	48.1	0.34

SCALE: Linear

DATE: 19-FEB-88

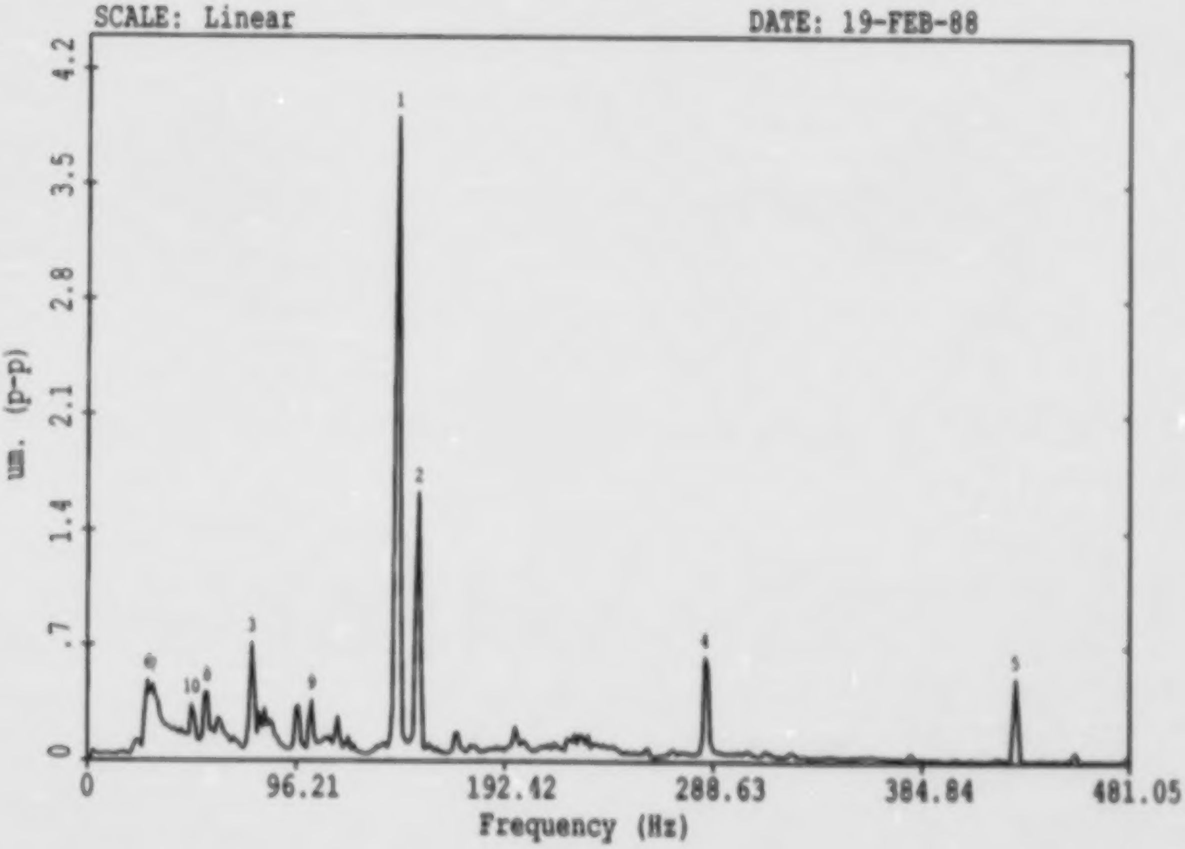
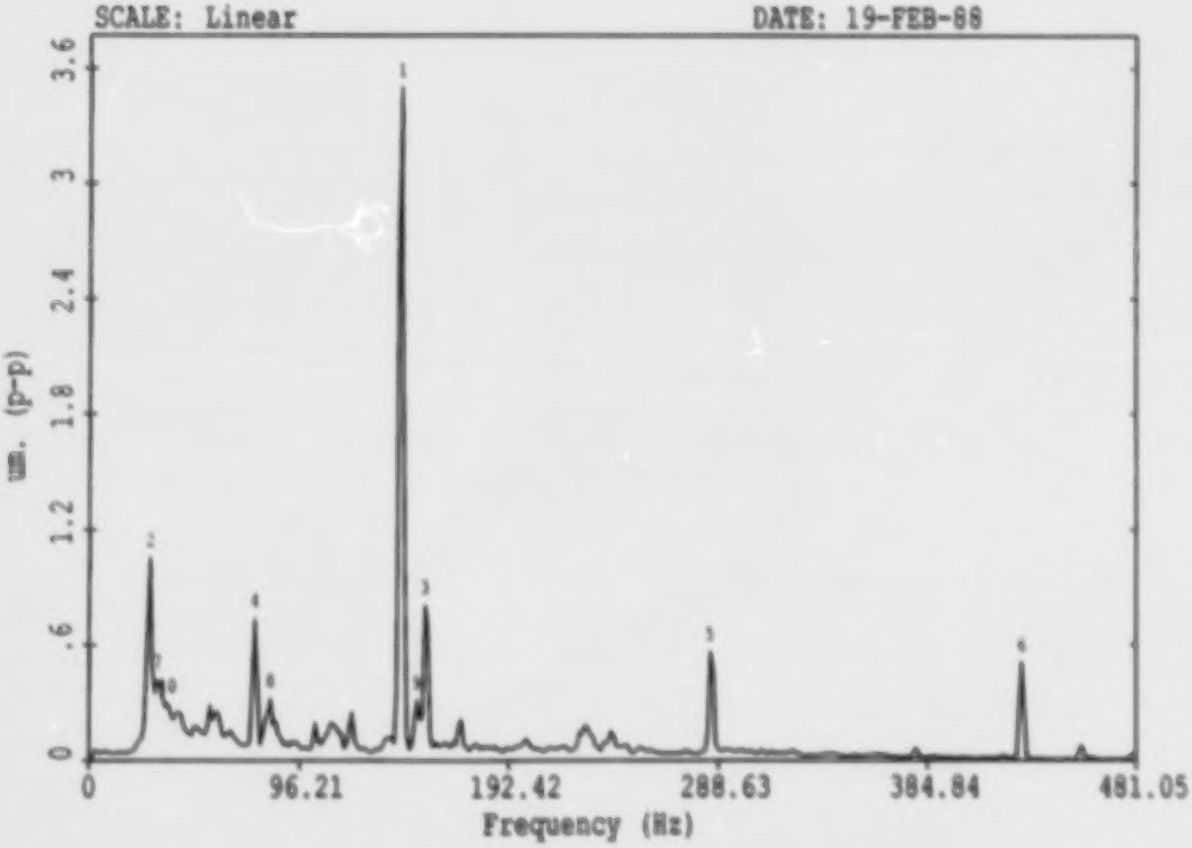


FIGURE D34

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.50
2	27.7	1.06
3	153.9	0.81
4	75.8	0.74
5	285.0	0.57
6	428.1	0.51
7	31.3	0.42
8	83.0	0.33
9	150.3	0.32
10	36.1	0.30



SCALE: Linear

DATE: 19-FEB-88

FIGURE D35

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.37
2	27.7	1.45
3	75.8	0.76
4	56.5	0.62
5	285.0	0.55
6	428.1	0.51
7	2.4	0.47
8	31.3	0.45
9	156.3	0.40
10	84.2	0.38

SCALE: Linear

DATE: 19-FEB-88

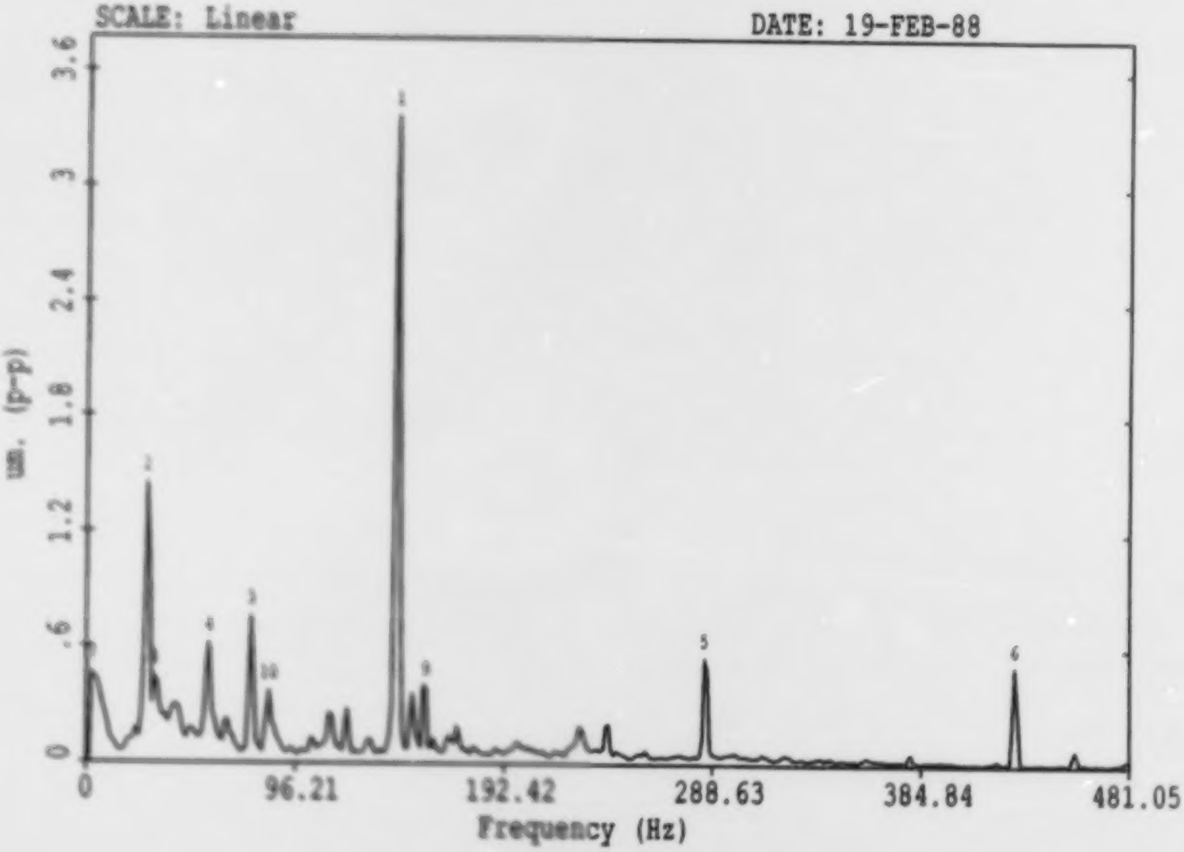


FIGURE D36

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.57
2	30.1	2.09
3	3.6	1.29
4	60.1	1.22
5	75.8	1.06
6	158.7	0.65
7	285.0	0.60
8	428.1	0.50
9	120.3	0.46
10	26.5	0.35

SCALE: Linear

DATE: 19-FEB-88

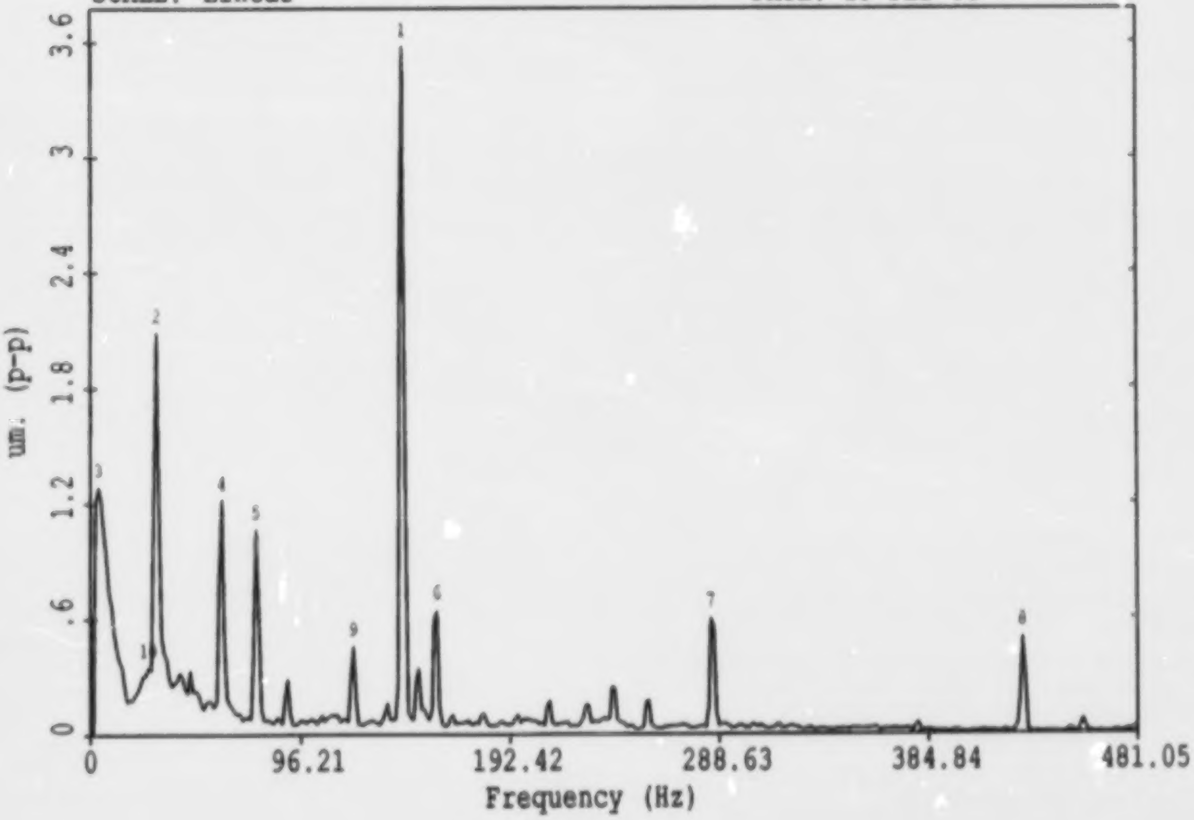


FIGURE D37

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.60
2	30.1	2.67
3	4.8	2.19
4	9.6	1.55
5	60.1	1.45
6	75.8	1.41
7	14.4	0.81
8	33.7	0.73
9	25.3	0.69
10	161.2	0.57

SCALE: Linear

DATE: 19-FEB-88

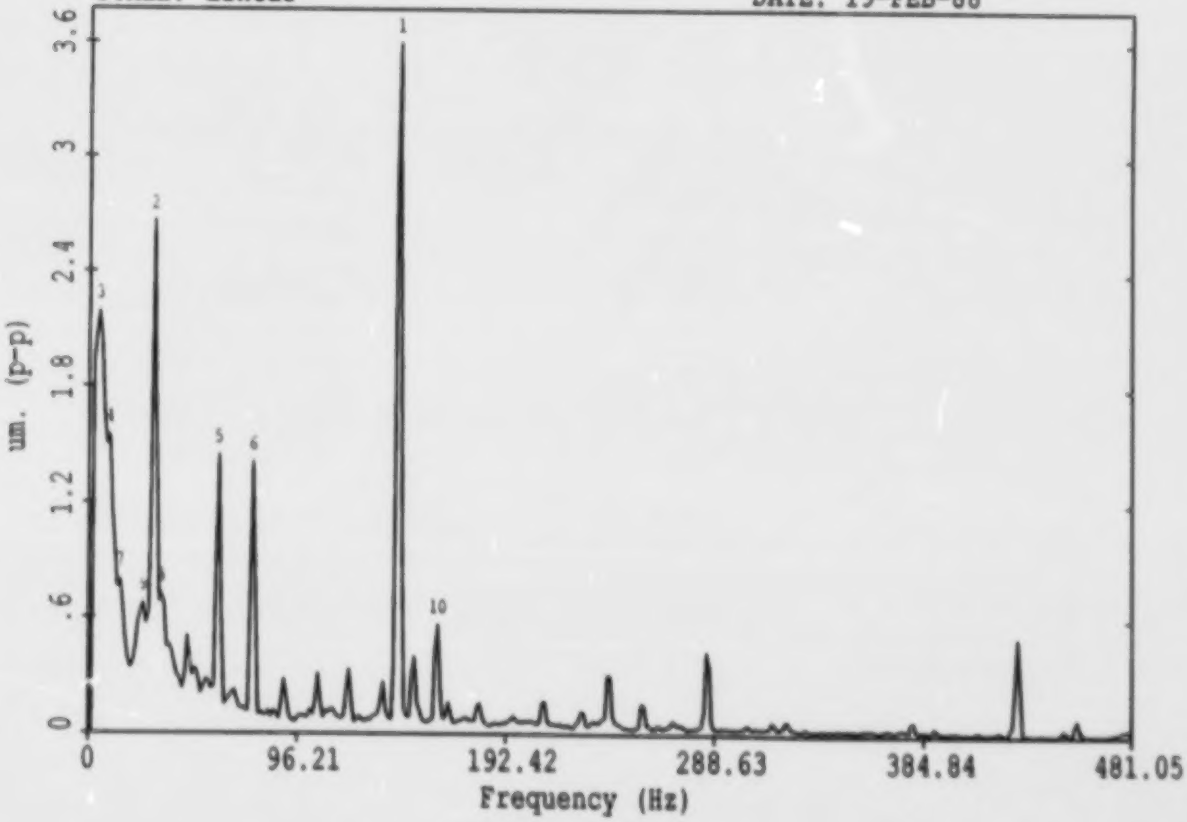


FIGURE D38

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.72
2	30.1	3.61
3	3.6	1.81
4	75.8	1.80
5	6.0	1.66
6	9.6	1.01
7	162.4	0.85
8	60.1	0.74
9	105.8	0.55
10	428.1	0.51

SCALE: Linear

DATE: 19-FEB-88

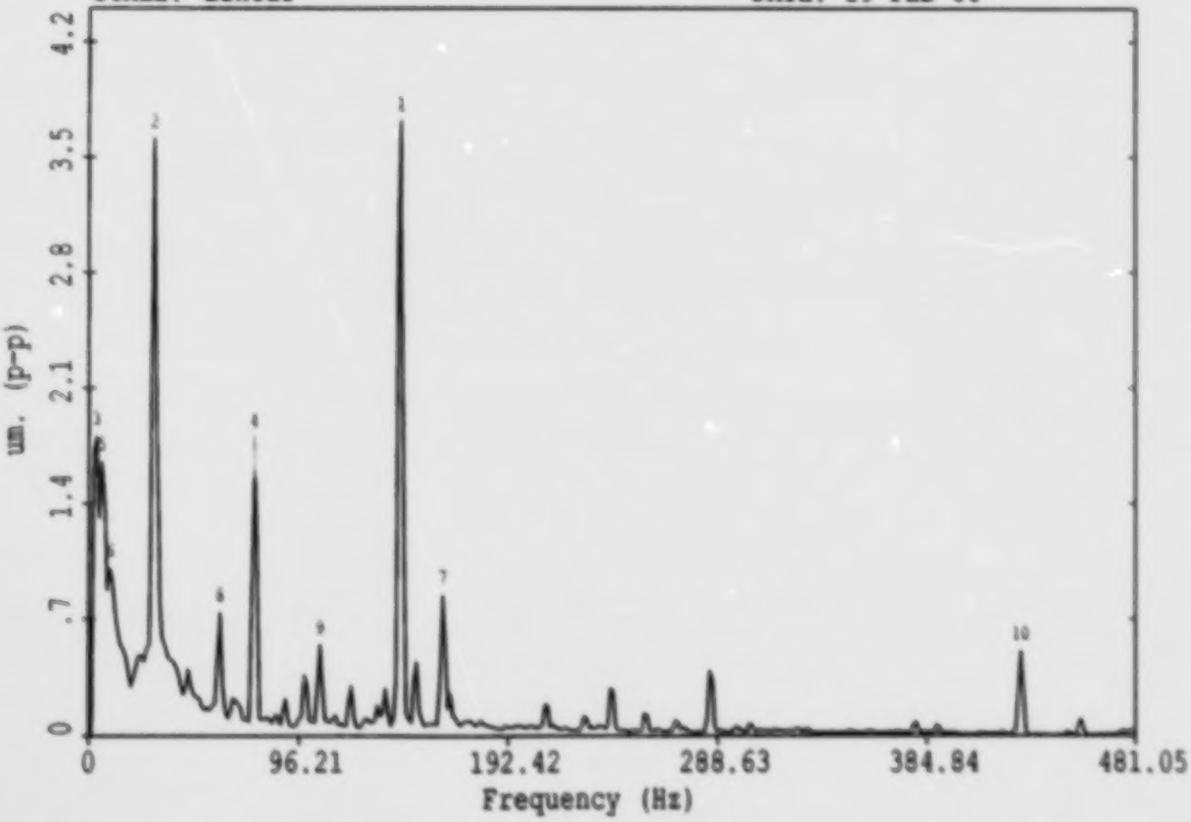


FIGURE D39

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #4 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	3.91
2	30.1	3.34
3	75.8	2.64
4	167.2	1.53
5	3.6	1.52
6	6.0	1.47
7	60.1	0.92
8	13.2	0.79
9	38.5	0.69
10	24.1	0.59

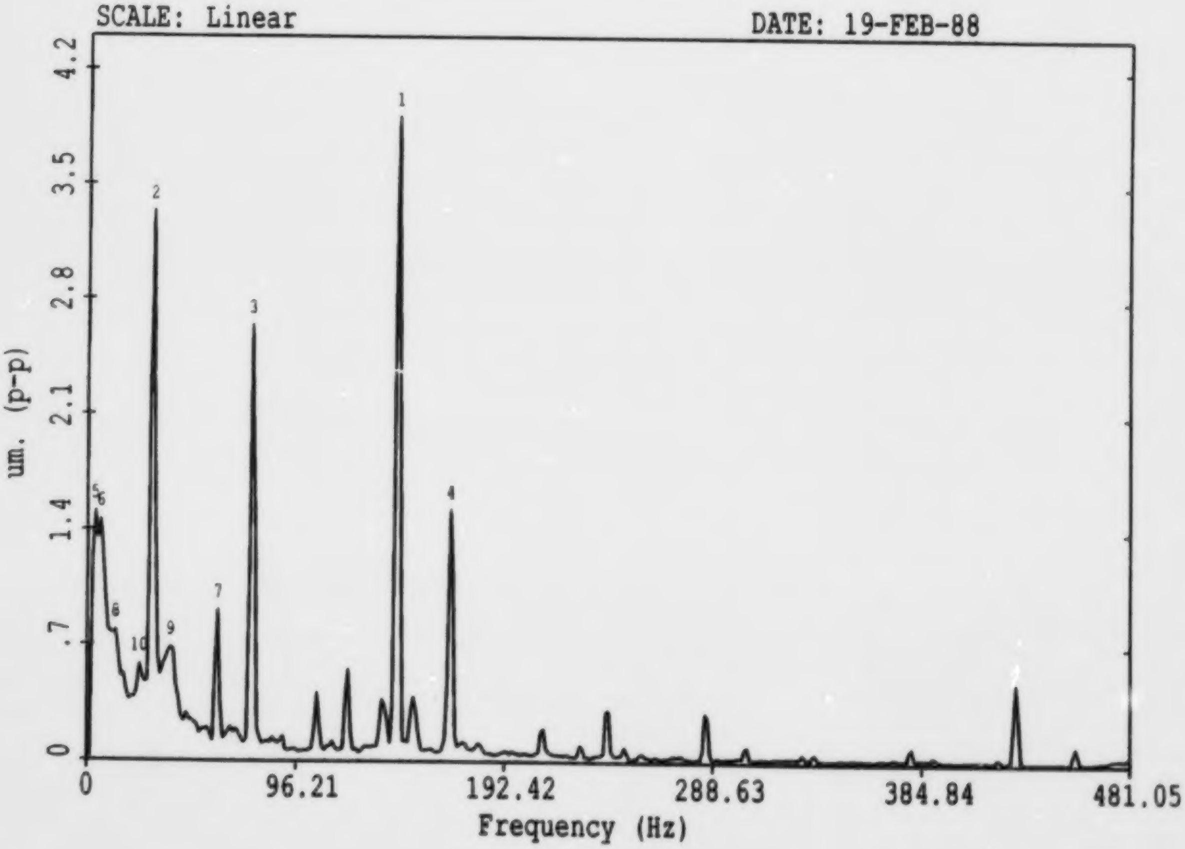


FIGURE D40

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	7.26
2	286.2	1.73
3	429.3	1.40
4	147.9	1.23
5	60.1	0.61
6	218.9	0.47
7	30.1	0.37
8	152.7	0.27
9	203.2	0.25
10	45.7	0.20

SCALE: Linear

DATE: 19-FEB-88

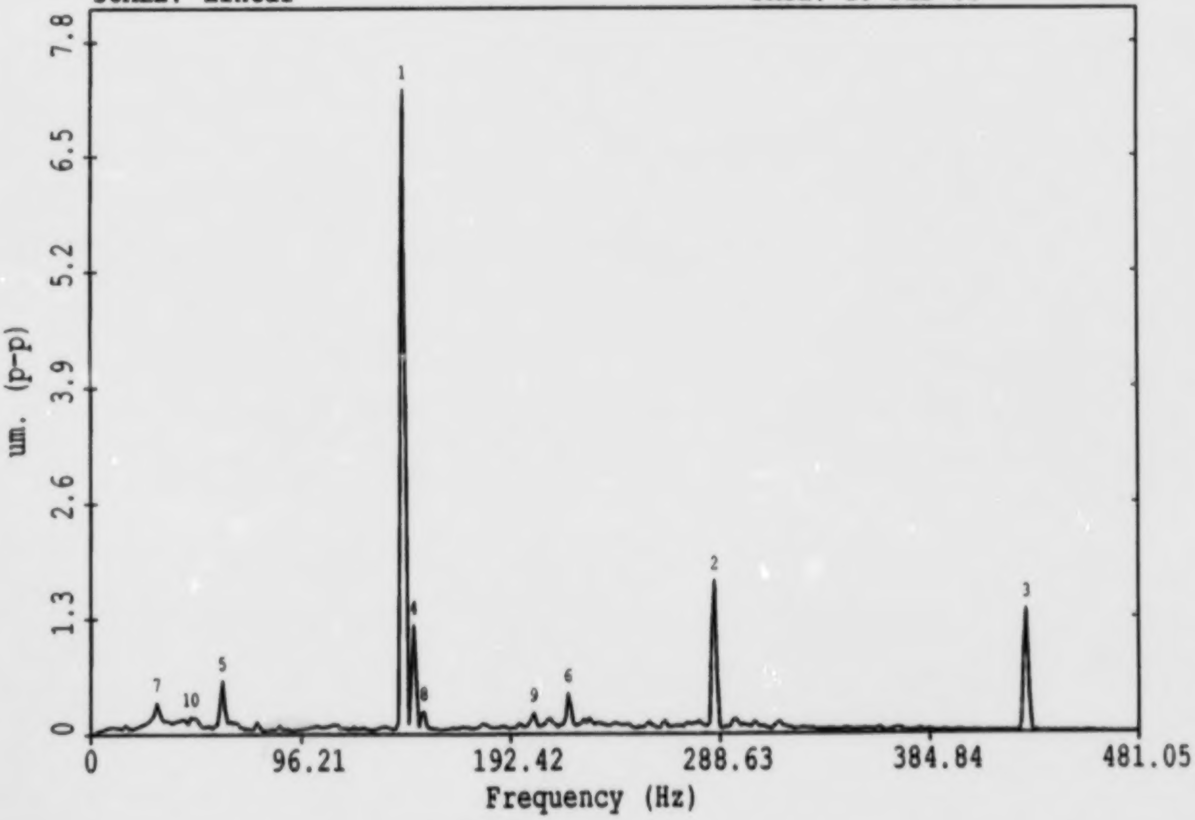


FIGURE D41

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	7.17
2	285.0	2.15
3	54.1	1.81
4	428.1	1.65
5	27.7	1.29
6	75.8	0.72
7	152.7	0.61
8	197.2	0.60
9	169.6	0.59
10	115.5	0.57

SCALE: Linear DATE: 19-FEB-88

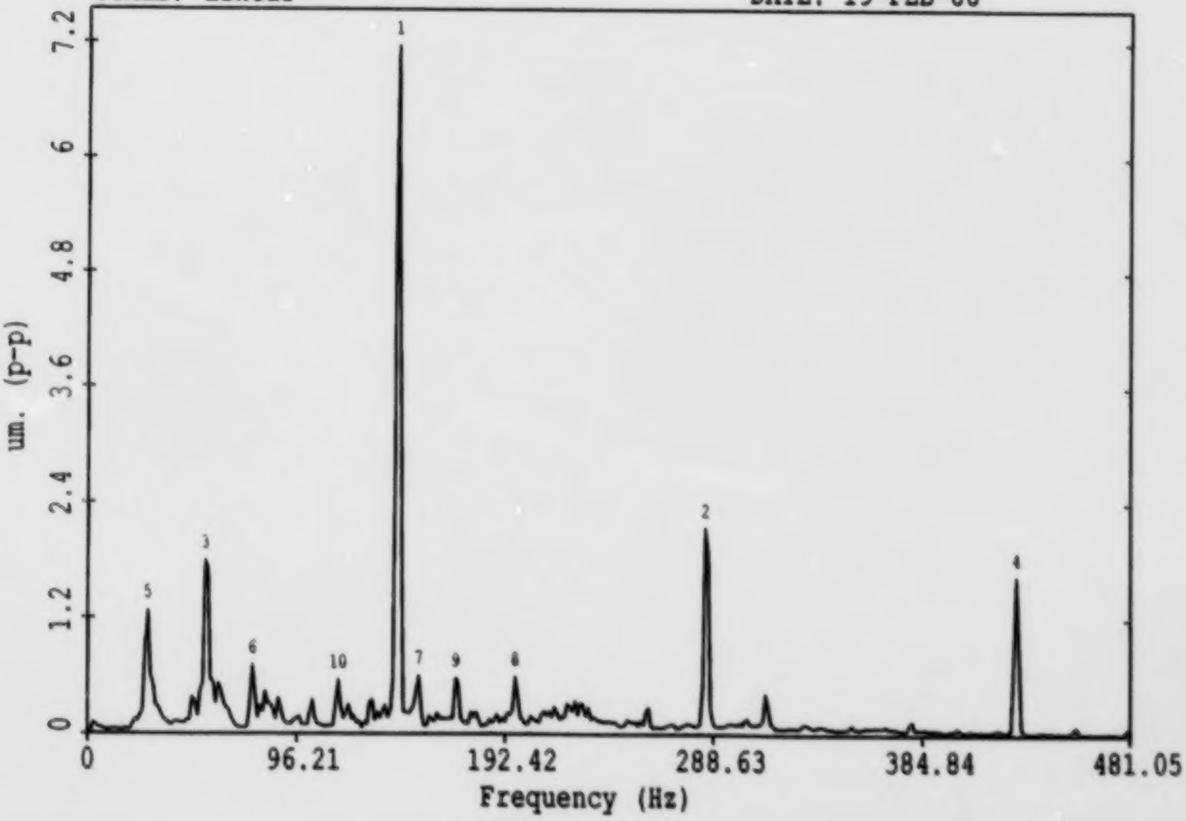


FIGURE D42

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	7.52
2	285.0	2.55
3	27.7	1.72
4	428.1	1.68
5	55.3	1.48
6	150.3	0.74
7	115.5	0.69
8	60.1	0.63
9	75.8	0.56
10	227.3	0.42

SCALE: Linear DATE: 19-FEB-88

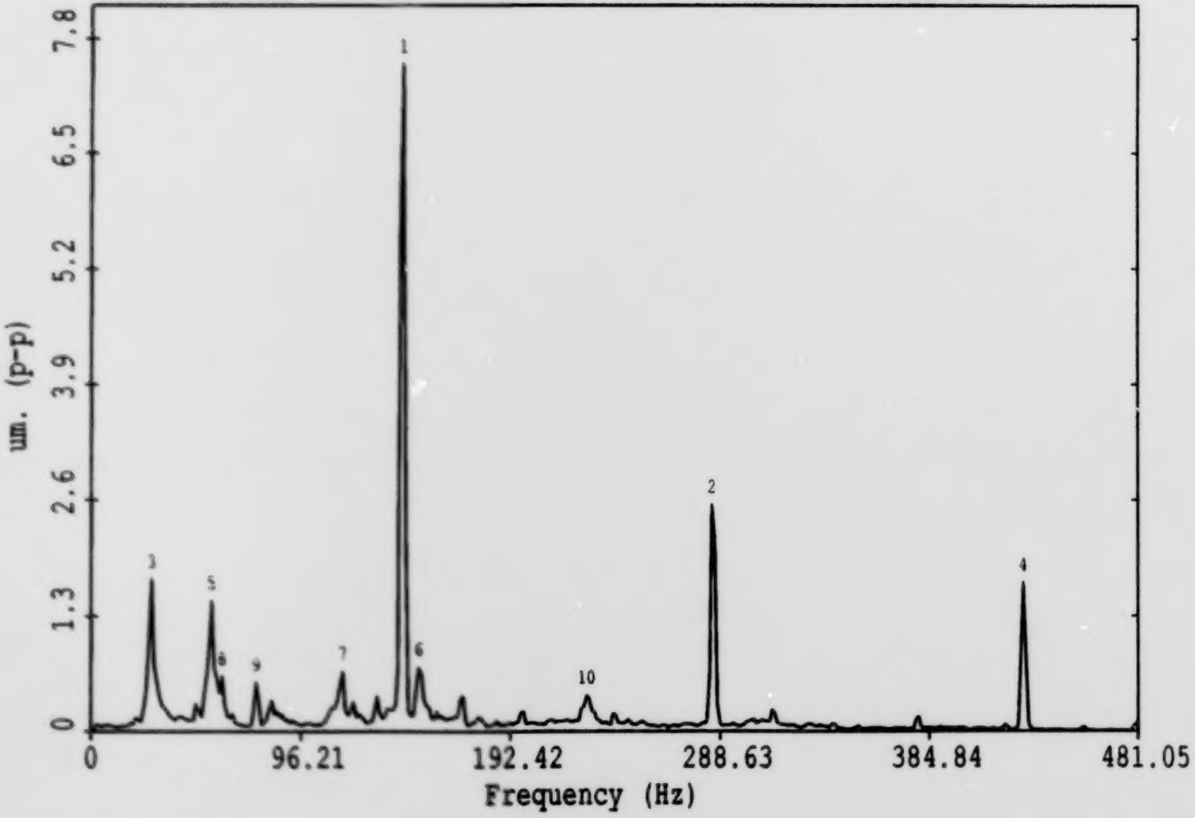


FIGURE D43

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	8.54
2	285.0	2.70
3	27.7	1.89
4	428.1	1.66
5	56.5	1.60
6	150.3	0.95
7	58.9	0.73
8	75.8	0.55
9	227.3	0.47
10	111.8	0.46

SCALE: Linear

DATE: 19-FEB-88

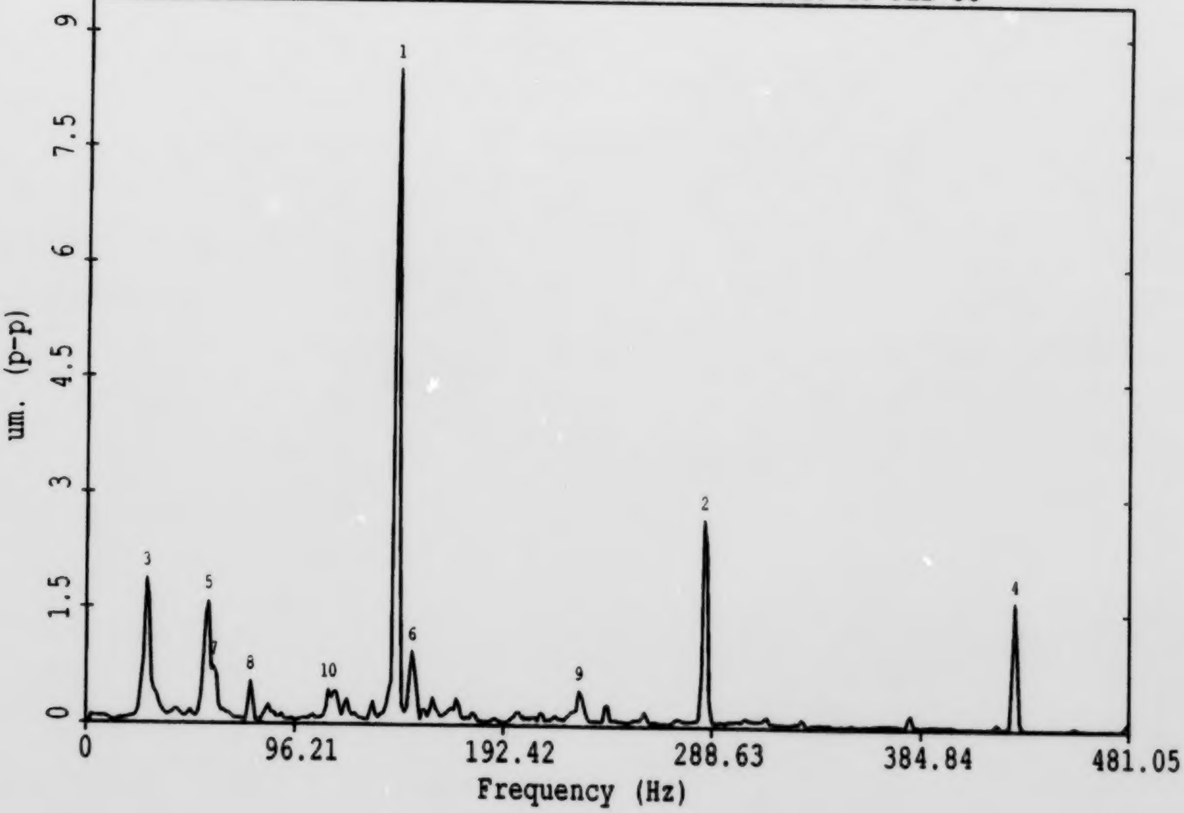


FIGURE D44

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	9.25
2	30.1	4.85
3	285.0	2.84
4	60.1	2.78
5	428.1	1.63
6	150.3	1.22
7	90.2	0.76
8	75.8	0.68
9	120.3	0.60
10	210.5	0.53

SCALE: Linear

DATE: 19-FEB-88

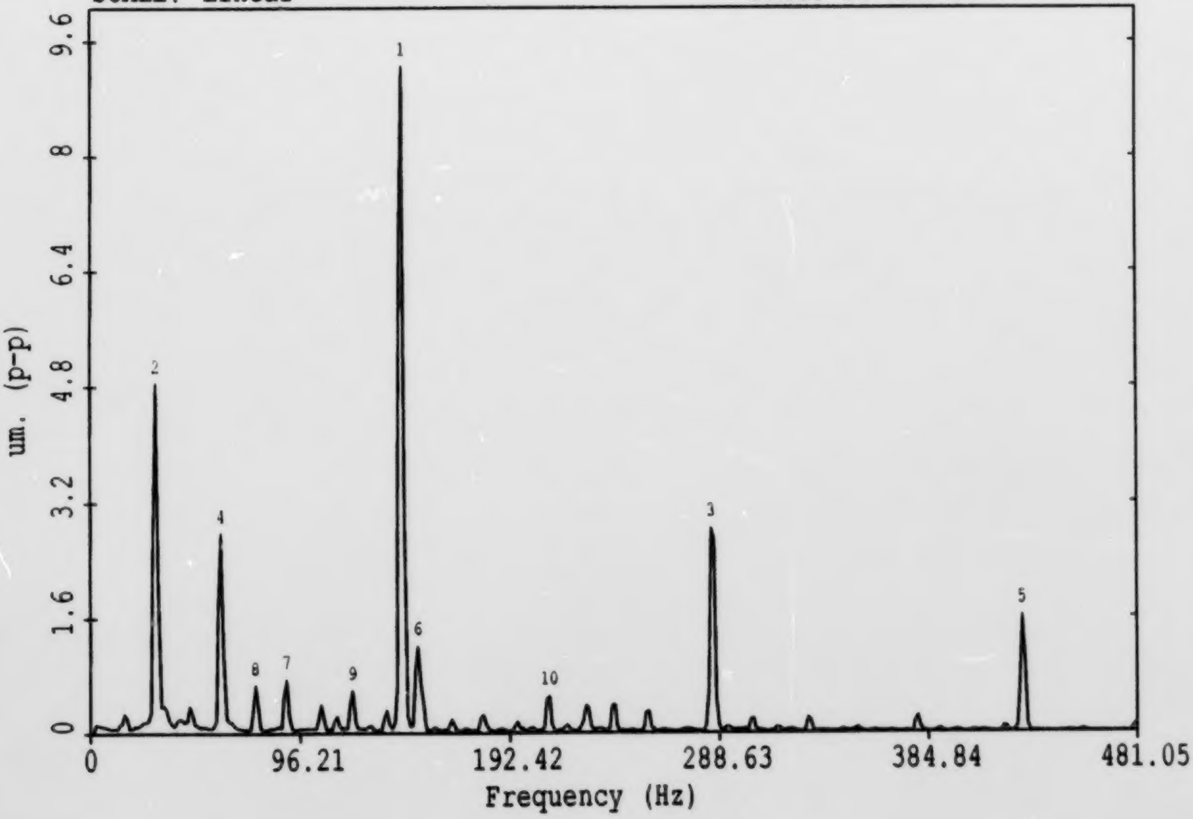


FIGURE D45

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	9.53
2	30.1	7.28
3	285.0	3.33
4	60.1	1.97
5	428.1	1.66
6	150.3	1.51
7	45.7	0.83
8	75.8	0.73
9	105.8	0.73
10	120.3	0.66

SCALE: Linear DATE: 19-FEB-88

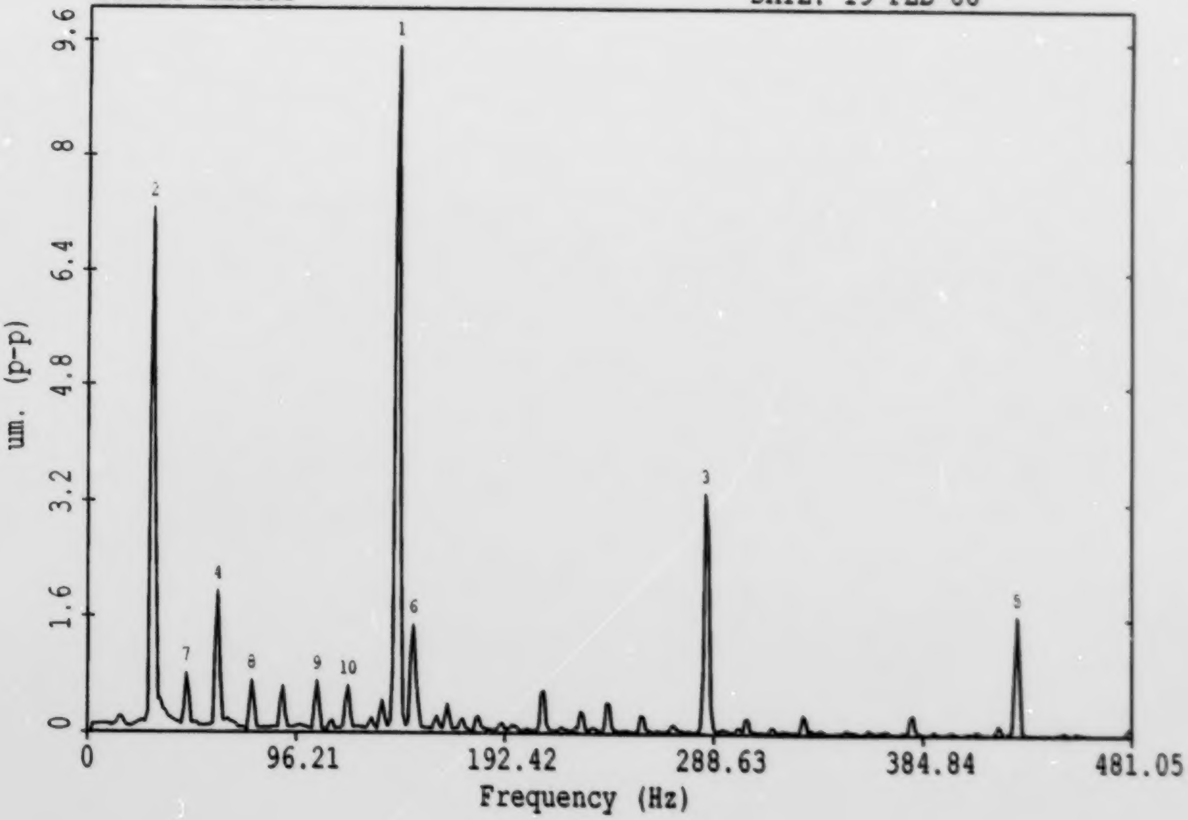


FIGURE D46

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	9.60
2	143.1	9.54
3	285.0	3.45
4	428.1	1.66
5	150.3	1.53
6	75.8	0.94
7	135.9	0.85
8	105.8	0.82
9	45.7	0.75
10	90.2	0.66

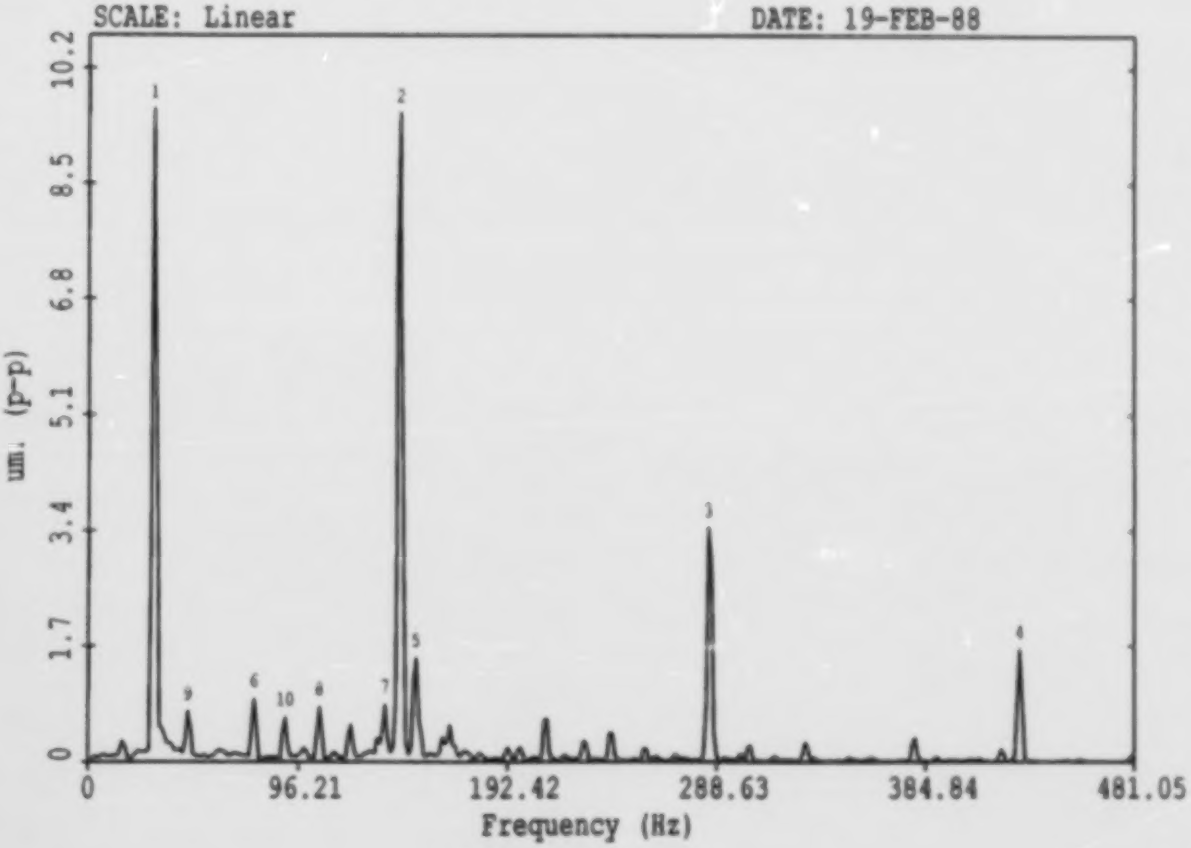


FIGURE D47

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	30.1	10.22
2	143.1	9.00
3	285.0	3.54
4	75.8	1.72
5	428.1	1.62
6	60.1	1.36
7	150.3	1.27
8	135.9	0.90
9	167.2	0.65
10	210.5	0.62

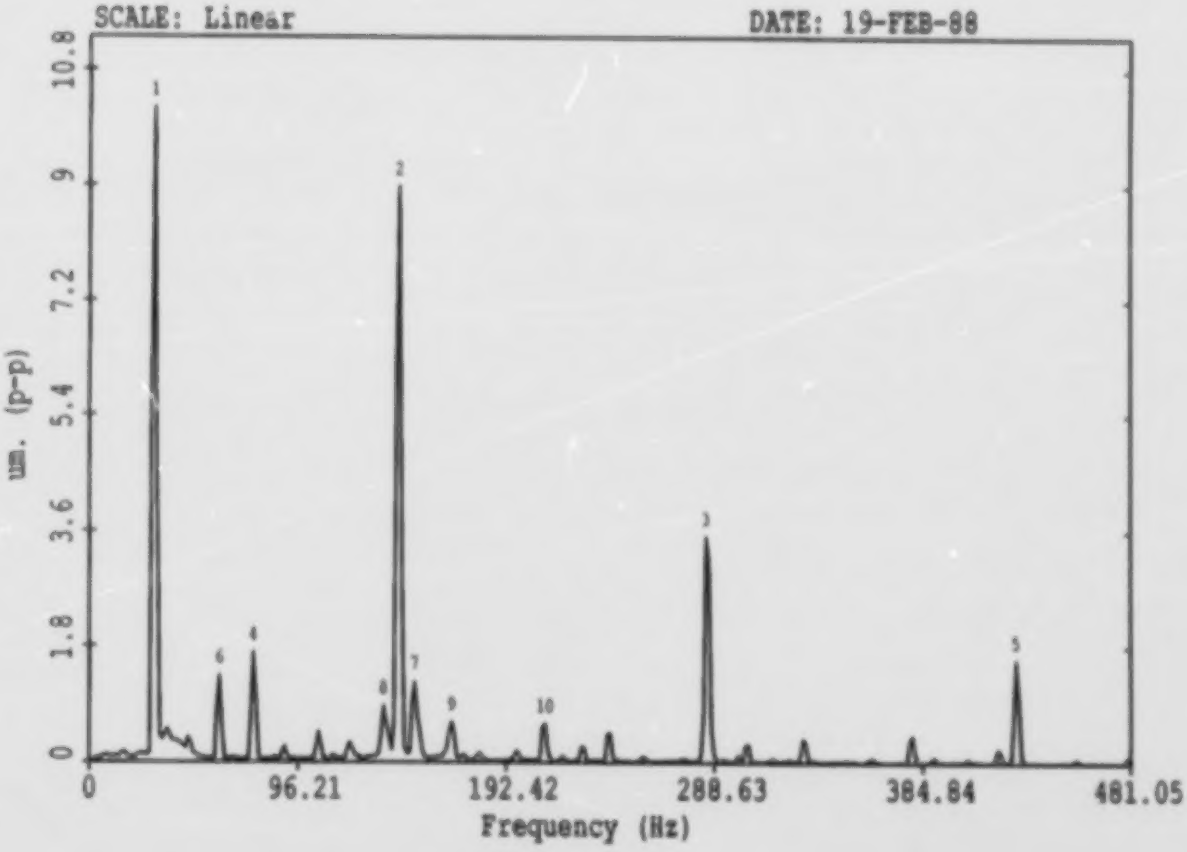


FIGURE D48

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	8.27
2	286.2	3.14
3	429.3	1.79
4	30.1	0.72
5	75.8	0.55
6	151.5	0.47
7	218.9	0.42
8	203.2	0.32
9	60.1	0.31
10	226.1	0.23

SCALE: Linear DATE: 19-FEB-88

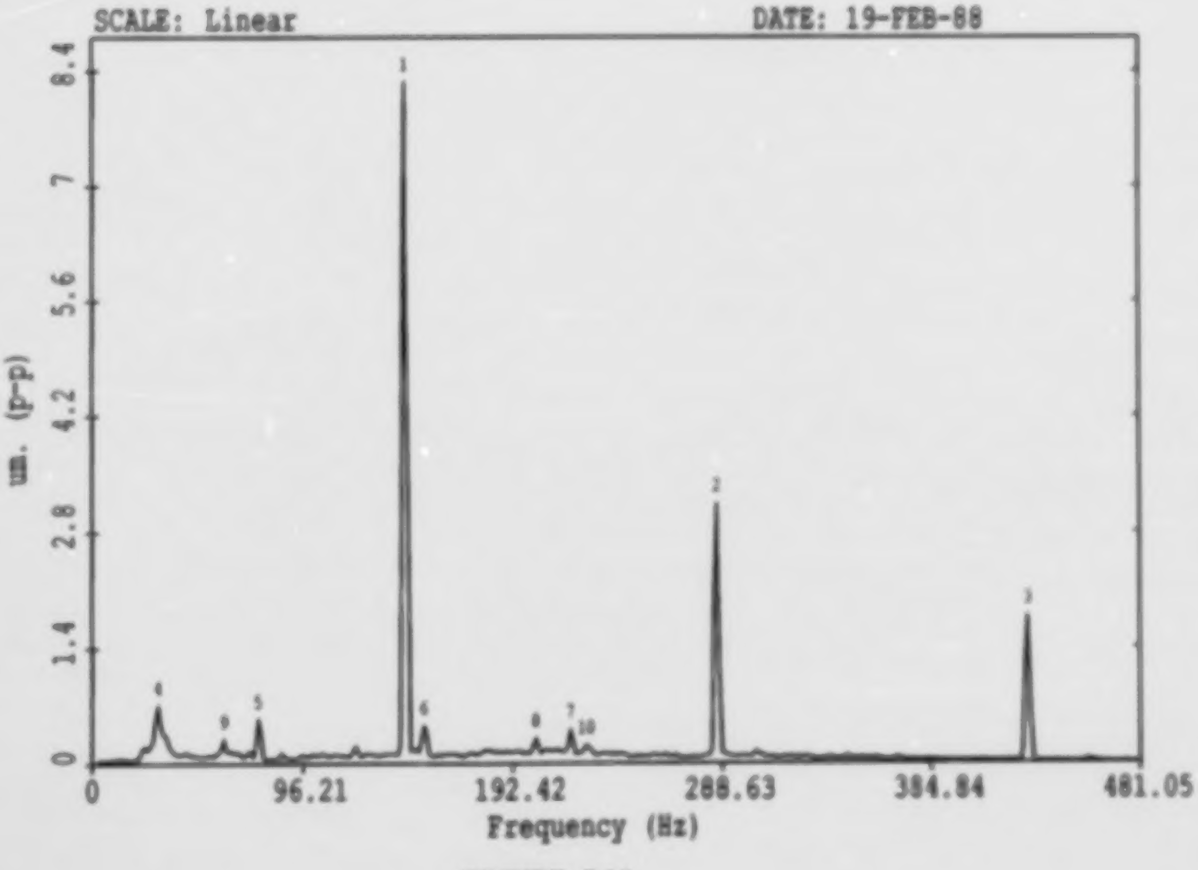


FIGURE D49

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	8.10
2	285.0	3.49
3	428.1	1.63
4	27.7	1.38
5	54.1	1.36
6	75.8	1.12
7	115.5	0.85
8	30.1	0.82
9	60.1	0.64
10	197.2	0.55

SCALE: Linear

DATE: 19-FEB-88

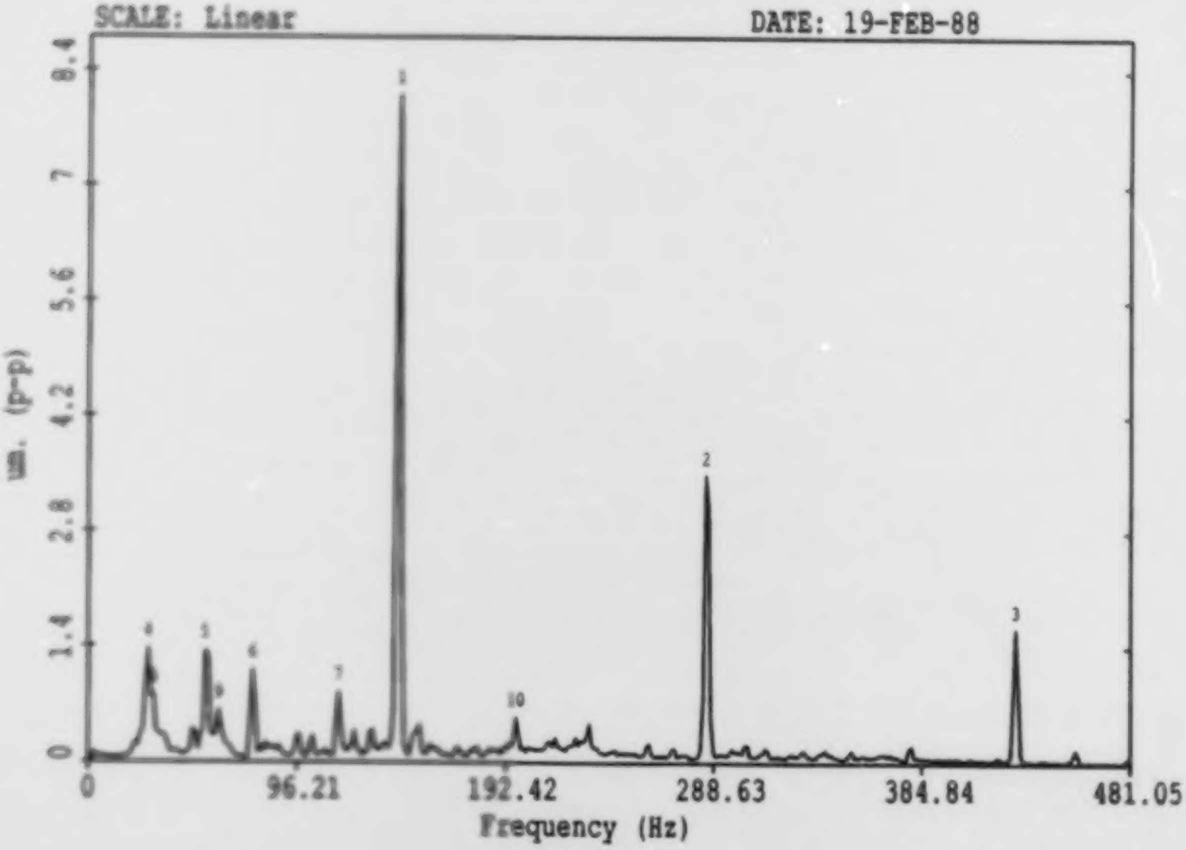


FIGURE D50

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	8.32
2	27.7	4.68
3	285.0	3.65
4	428.1	1.60
5	55.3	1.29
6	75.8	0.92
7	150.3	0.76
8	60.1	0.76
9	115.5	0.52
10	226.1	0.44

SCALE: Linear DATE: 19-FEB-88

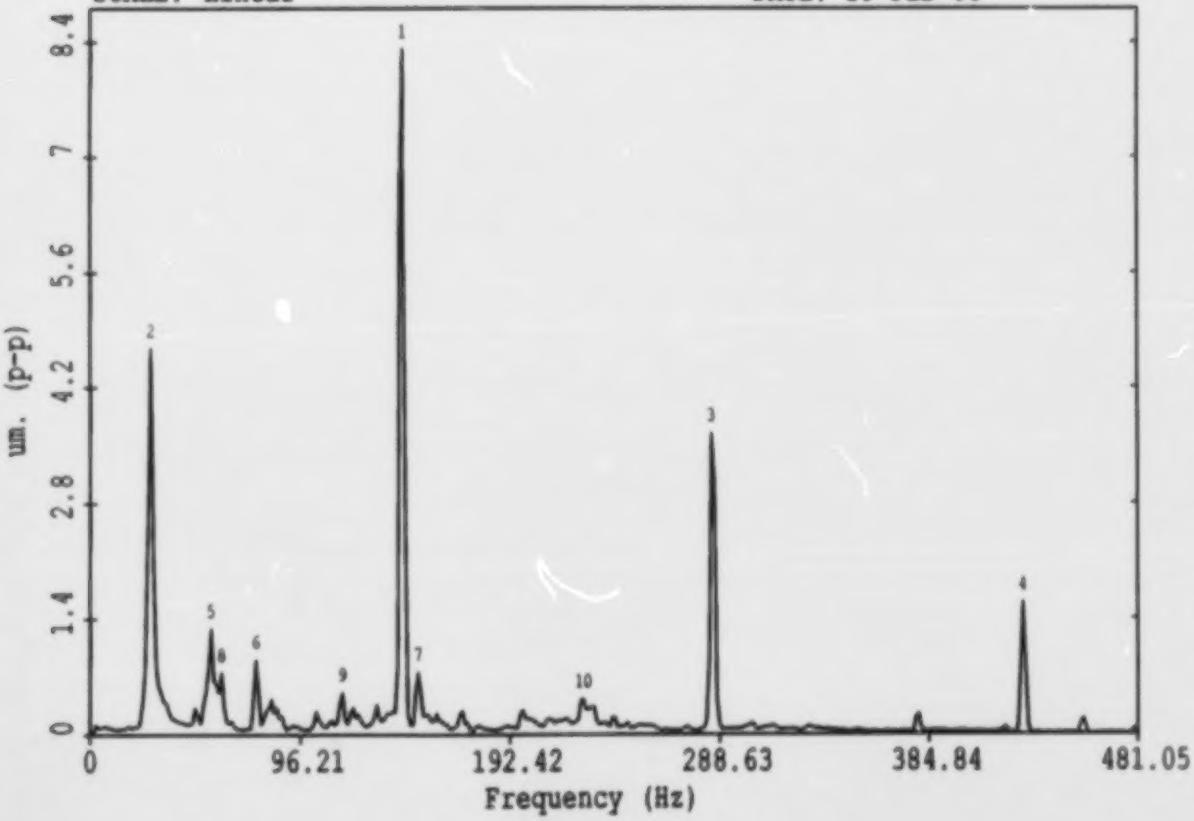


FIGURE D51

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	9.13
2	27.7	6.08
3	285.0	3.63
4	428.1	1.58
5	56.5	1.43
6	75.8	0.94
7	150.3	0.94
8	60.1	0.92
9	84.2	0.60
10	227.3	0.42

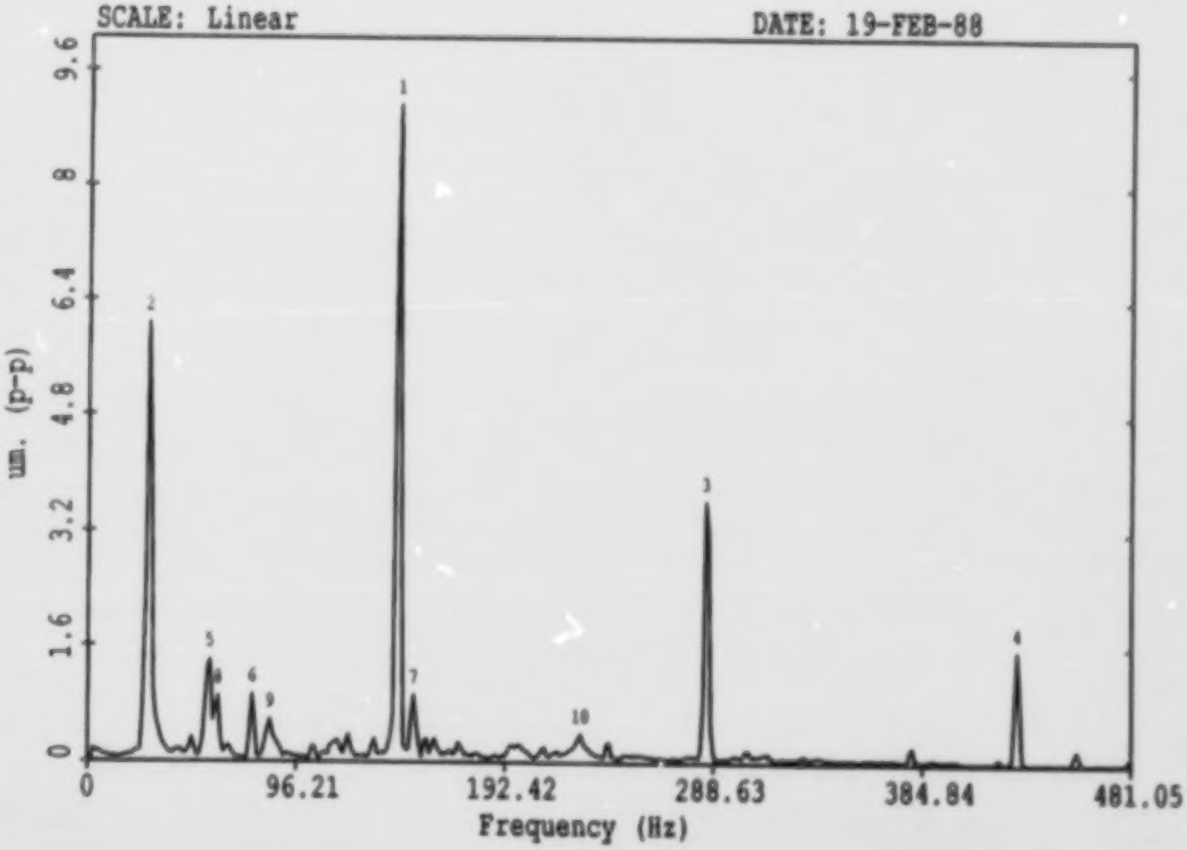


FIGURE D52

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	9.58
2	60.1	4.24
3	285.0	3.52
4	30.1	2.39
5	428.1	1.54
6	75.8	1.28
7	150.3	1.06
8	120.3	0.70
9	240.5	0.43
10	45.7	0.43

SCALE: Linear DATE: 19-FEB-88

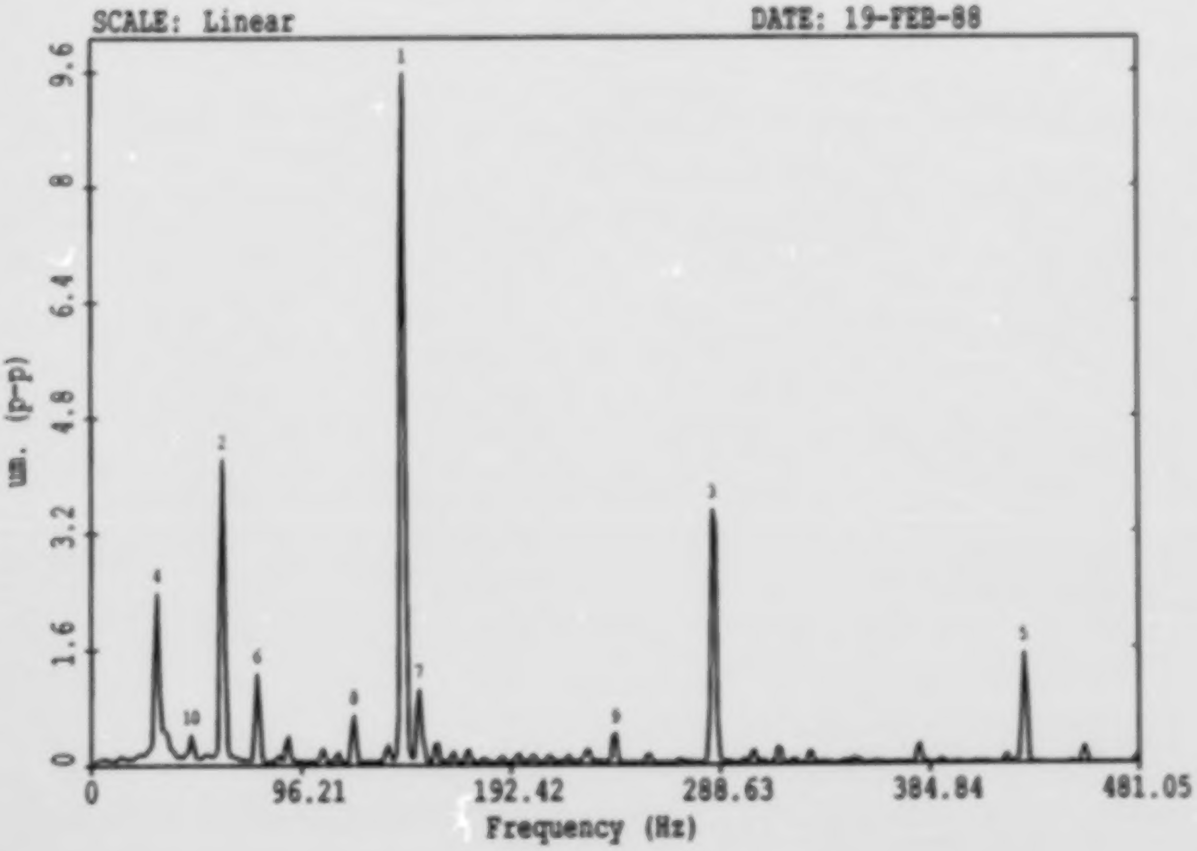


FIGURE D53

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	10.36
2	285.0	3.69
3	30.1	1.68
4	150.3	1.67
5	428.1	1.56
6	75.8	1.43
7	120.3	0.94
8	45.7	0.81
9	90.2	0.76
10	33.7	0.72

SCALE: Linear

DATE: 19-FEB-88

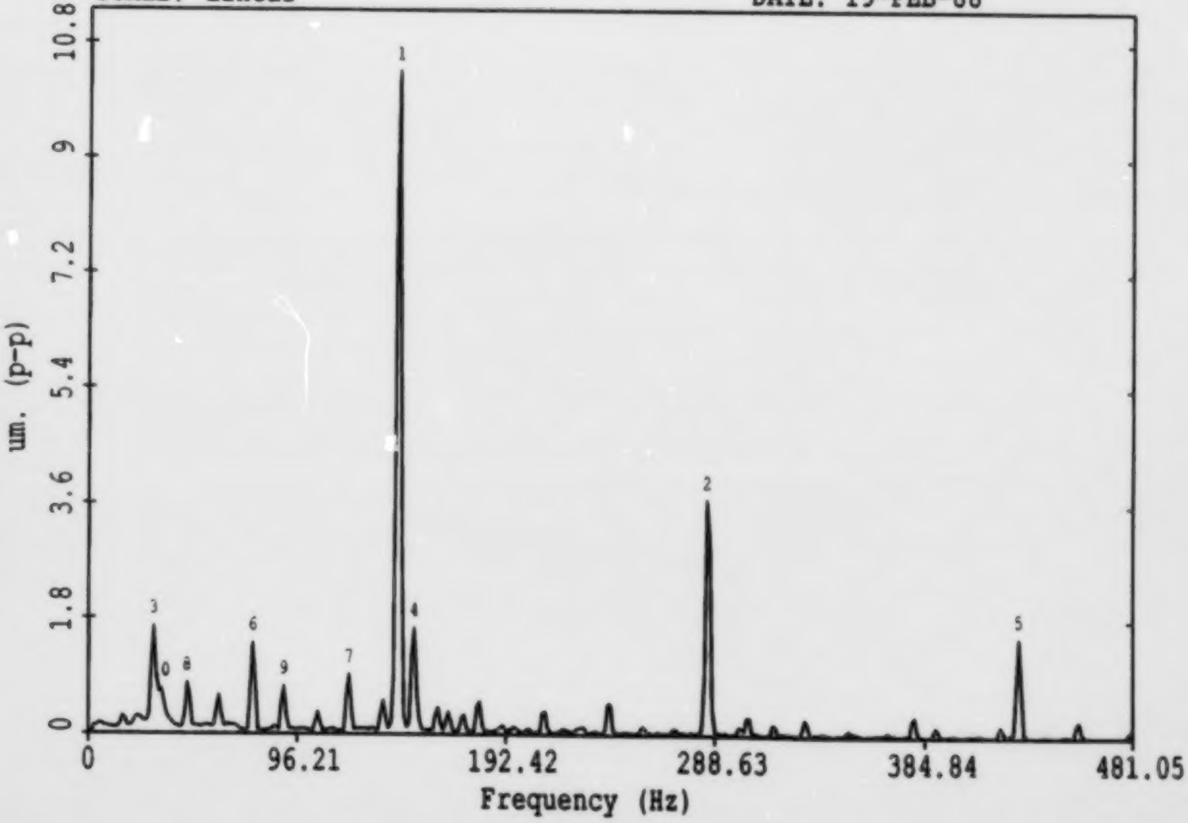
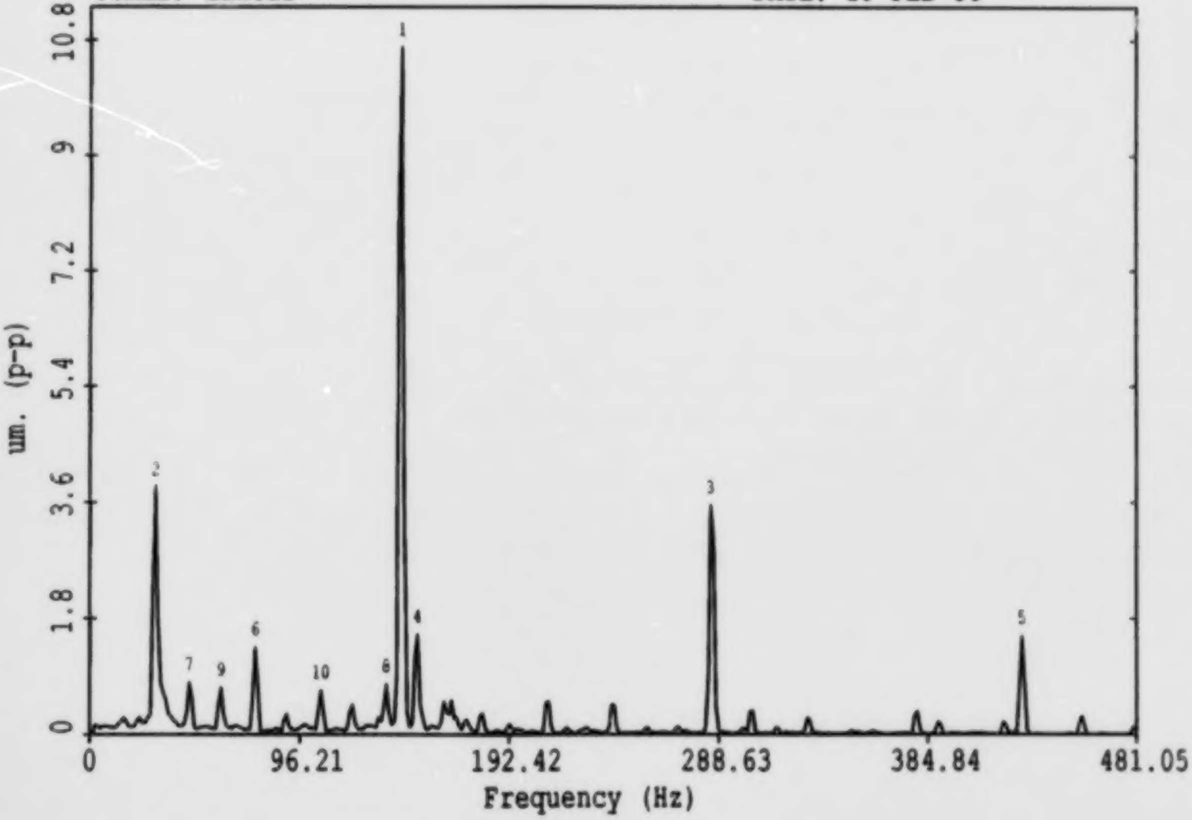


FIGURE D54

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	10.70
2	30.1	3.85
3	285.0	3.57
4	150.3	1.57
5	428.1	1.54
6	75.8	1.38
7	45.7	0.83
8	135.9	0.81
9	60.1	0.75
10	105.8	0.71



SCALE: Linear DATE: 19-FEB-88

FIGURE D55

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : PT BEARING #5 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	143.1	10.52
2	30.1	5.31
3	285.0	3.24
4	428.1	1.55
5	150.3	1.46
6	75.8	1.38
7	120.3	1.07
8	210.5	0.93
9	135.9	0.80
10	167.2	0.73

SCALE: Linear

DATE: 19-FEB-88

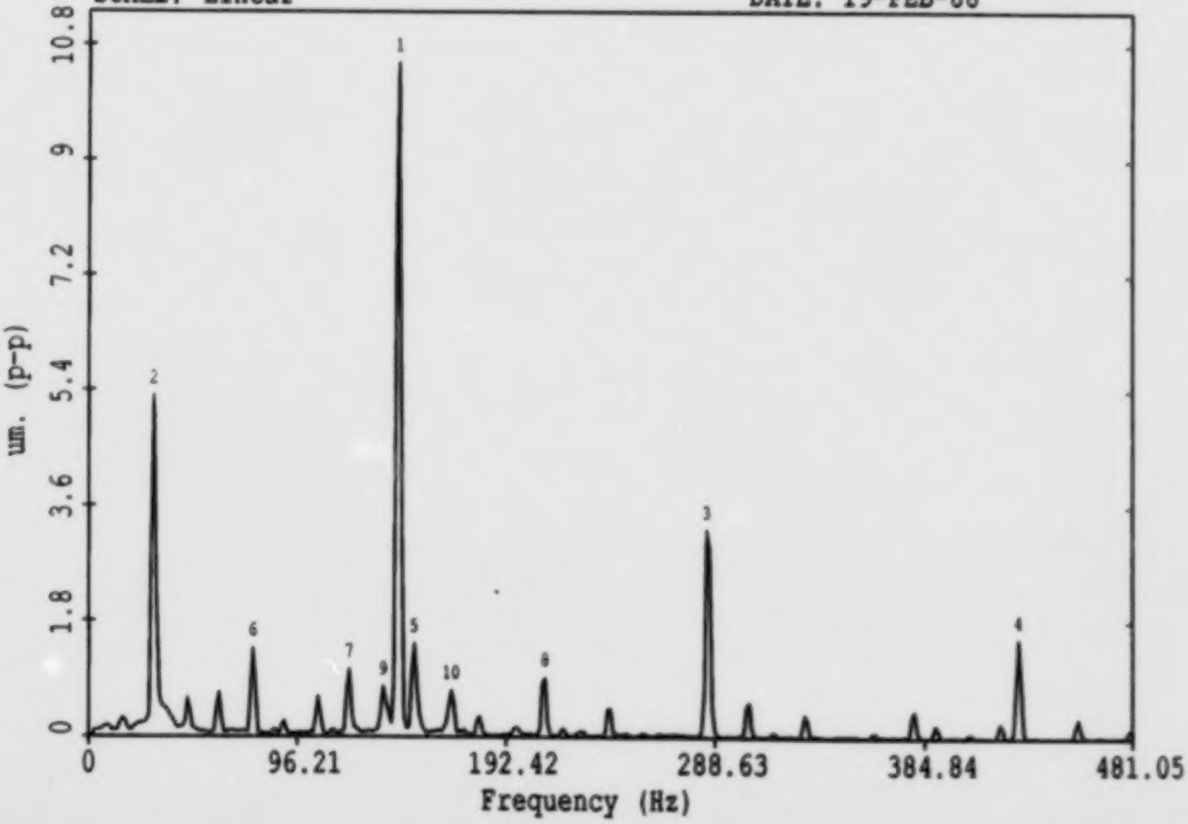


FIGURE D56

APPENDIX E

ACCESSORY GEARBOX VELOCITY SPECTRA

TABLE E1
DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2 - ACCESSORY GEARBOX
FIGURE NUMBERS OF VELOCITY SPECTRA

Measurement		FFT Spectrum Figure No. Load (MW) 0	1	1.5	2	3	4	5	6.8
Accessory Gearbox Casing Velocity	Vertical Direction	-	-	E1	E2	E3	E4	E5	E6
	Horizontal Direction	-	-	E7	E8	E9	E10	E11	E12

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	153.9	0.83
2	288.6	0.20
3	60.1	0.10
4	3.6	0.10
5	51.7	0.09
6	6.0	0.08
7	57.7	0.07
8	55.3	0.06
9	75.8	0.06
10	214.1	0.06

SCALE: Linear

DATE: 19-FEB-88

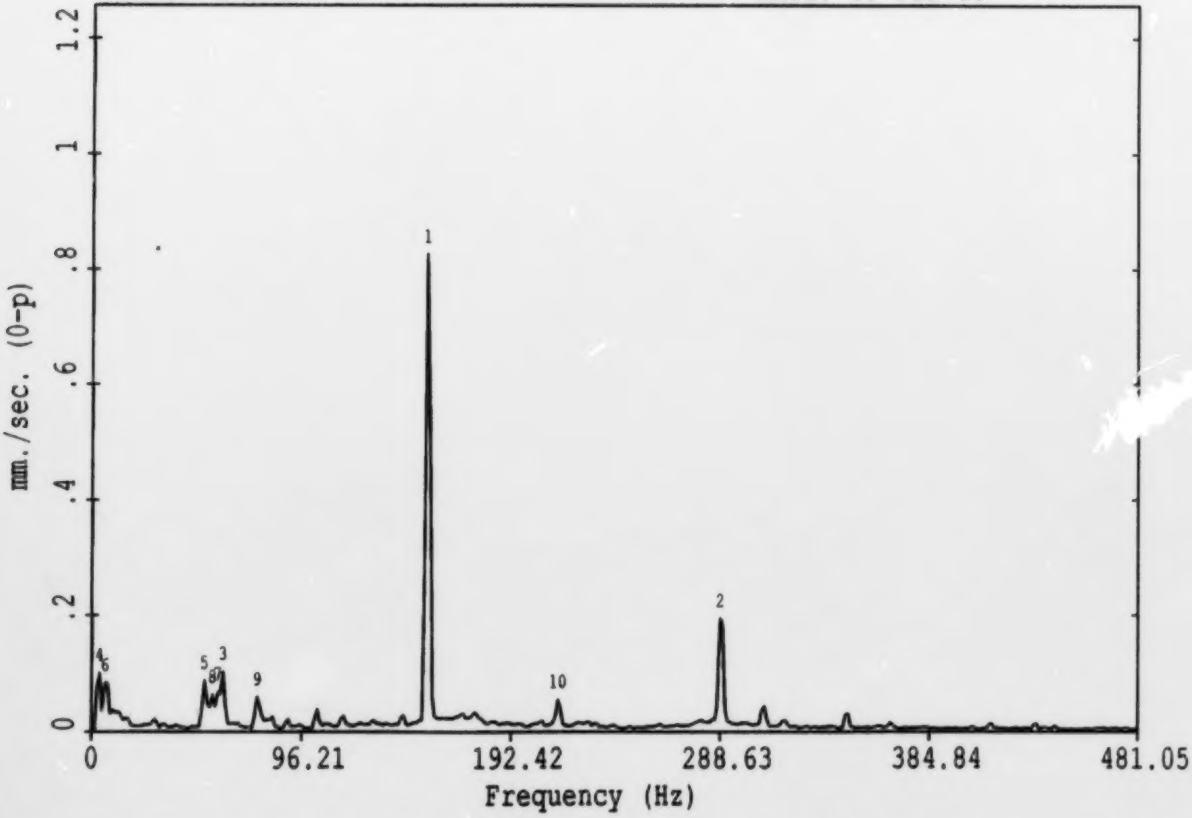


FIGURE E1

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	156.3	0.88
2	9.6	0.24
3	292.2	0.17
4	19.2	0.15
5	60.1	0.14
6	16.8	0.13
7	38.5	0.11
8	4.8	0.09
9	51.7	0.09
10	75.8	0.08

SCALE: Linear

DATE: 19-FEB-88

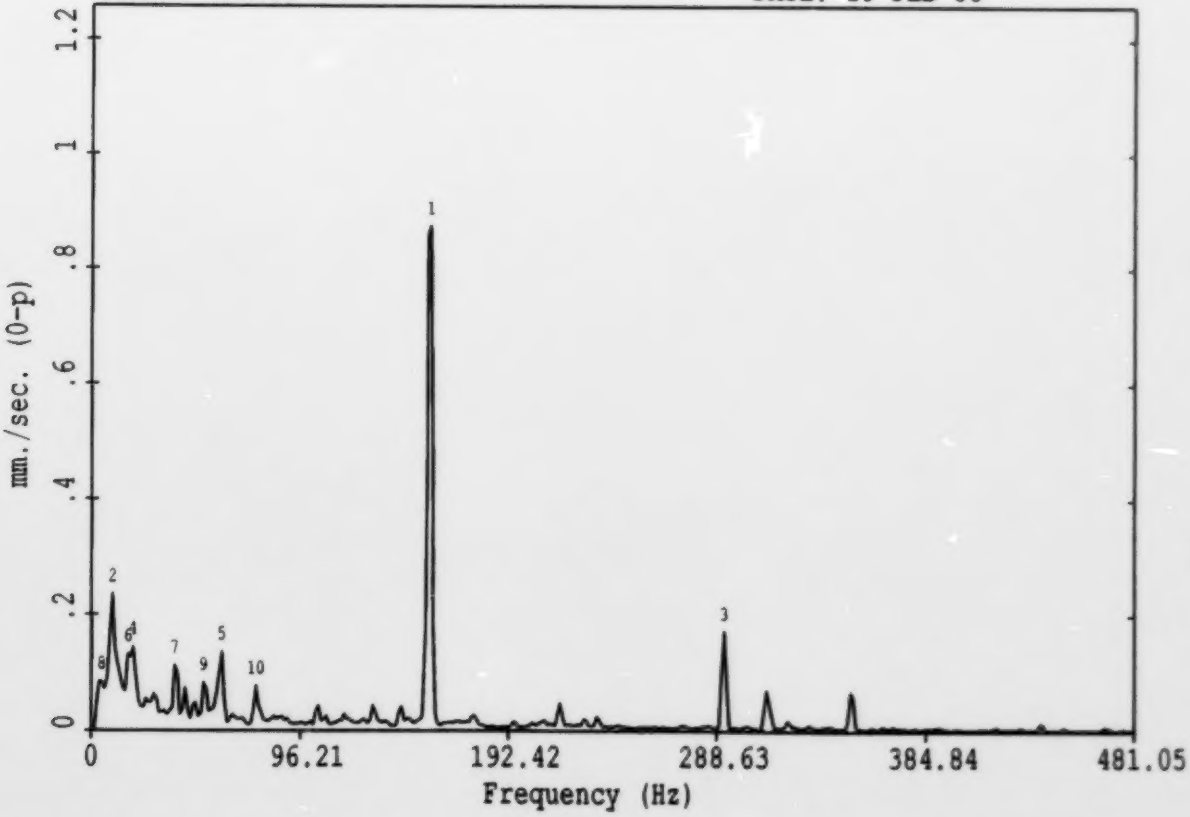
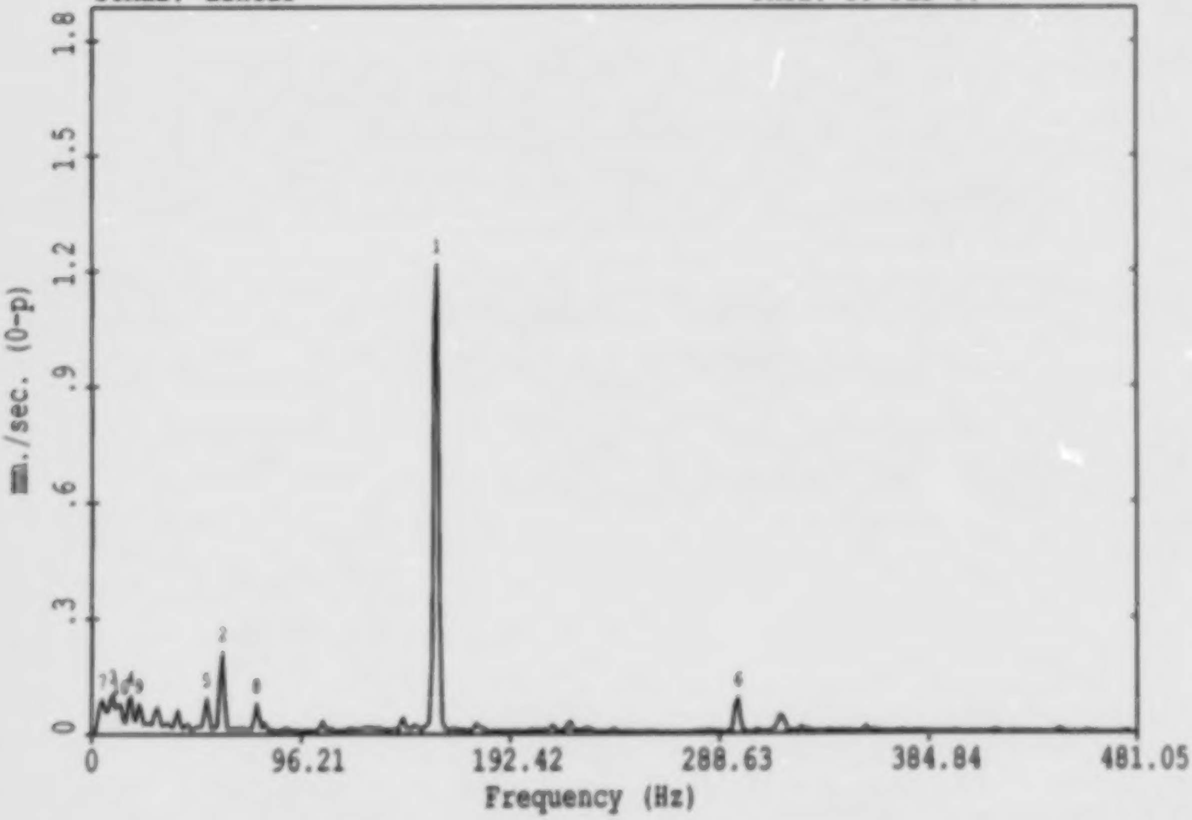


FIGURE E2

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : A[illegible]ORY GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOA[illegible]0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	158.7	1.22
2	60.1	0.22
3	9.6	0.11
4	18.0	0.10
5	52.9	0.10
6	297.1	0.10
7	4.8	0.09
8	75.8	0.08
9	21.6	0.08
10	13.2	0.08



SCALE: Linear

DATE: 19-FEB-88

FIGURE E3

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	161.2	1.66
2	22.9	0.14
3	301.9	0.14
4	60.1	0.11
5	30.1	0.09
6	54.1	0.08
7	321.1	0.08
8	75.8	0.07
9	12.0	0.06
10	8.4	0.06

SCALE: Linear DATE: 19-FEB-88

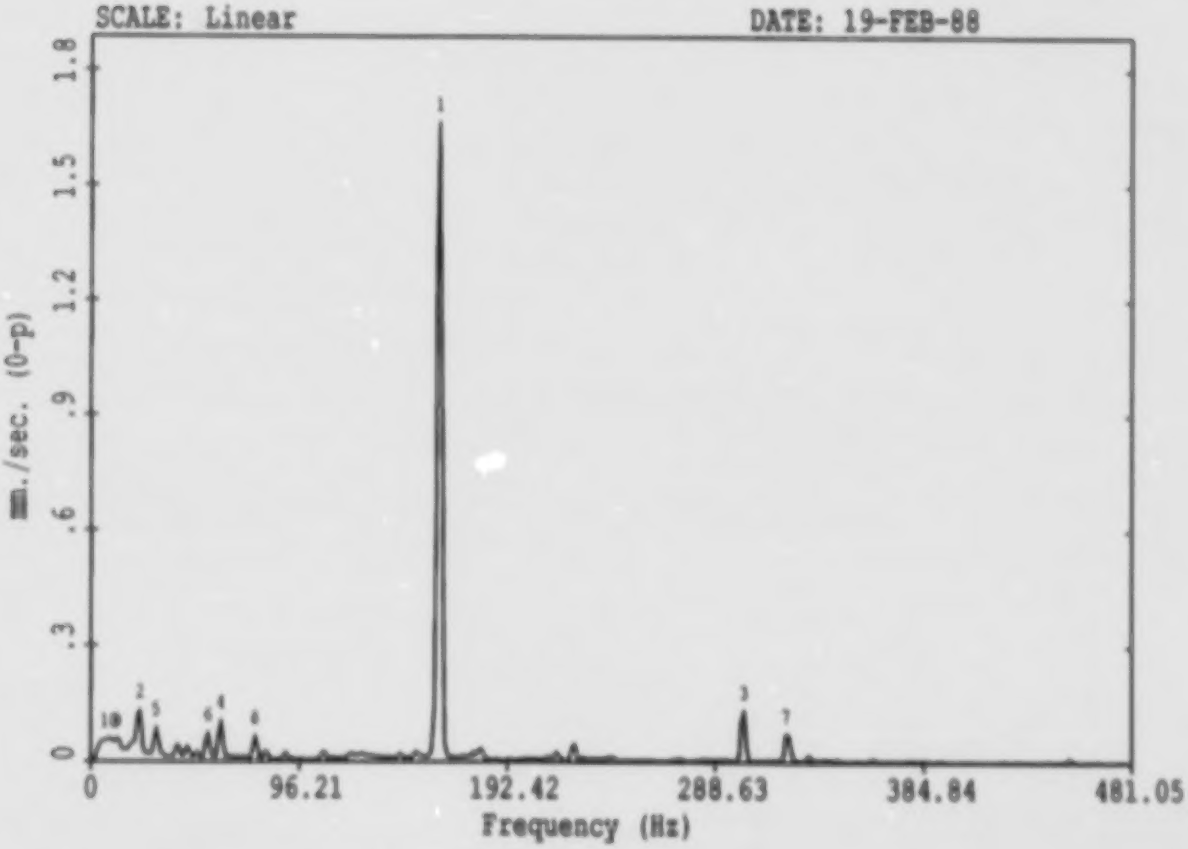


FIGURE E4

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	162.4	1.72
2	22.9	0.20
3	304.3	0.12
4	30.1	0.10
5	54.1	0.09
6	60.1	0.09
7	75.8	0.08
8	324.7	0.08
9	7.2	0.07
10	44.5	0.06

SCALE: Linear DATE: 19-FEB-88

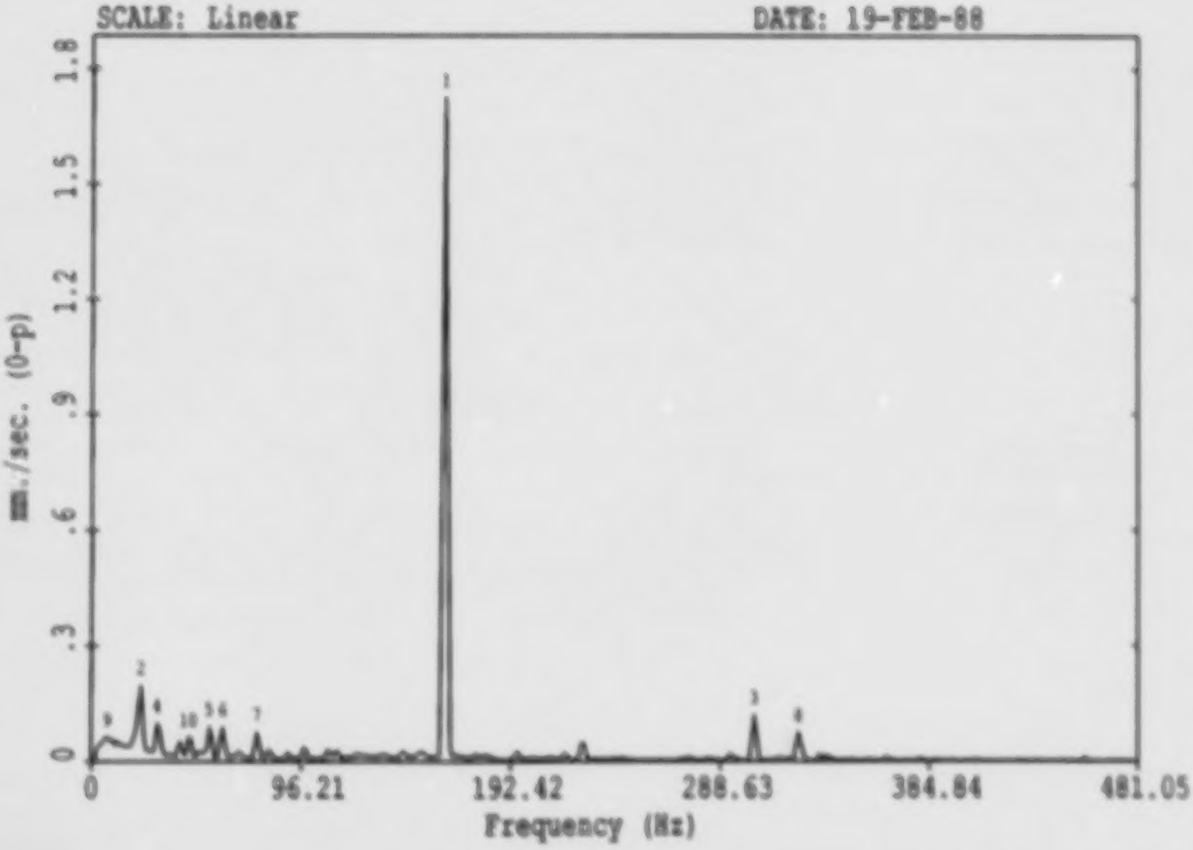


FIGURE E5

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY VERT.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	168.4	1.63
2	56.5	0.14
3	12.0	0.12
4	46.9	0.10
5	31.3	0.09
6	378.8	0.08
7	60.1	0.08
8	143.1	0.07
9	4.8	0.07
10	113.0	0.06

SCALE: Linear DATE: 19-FEB-88

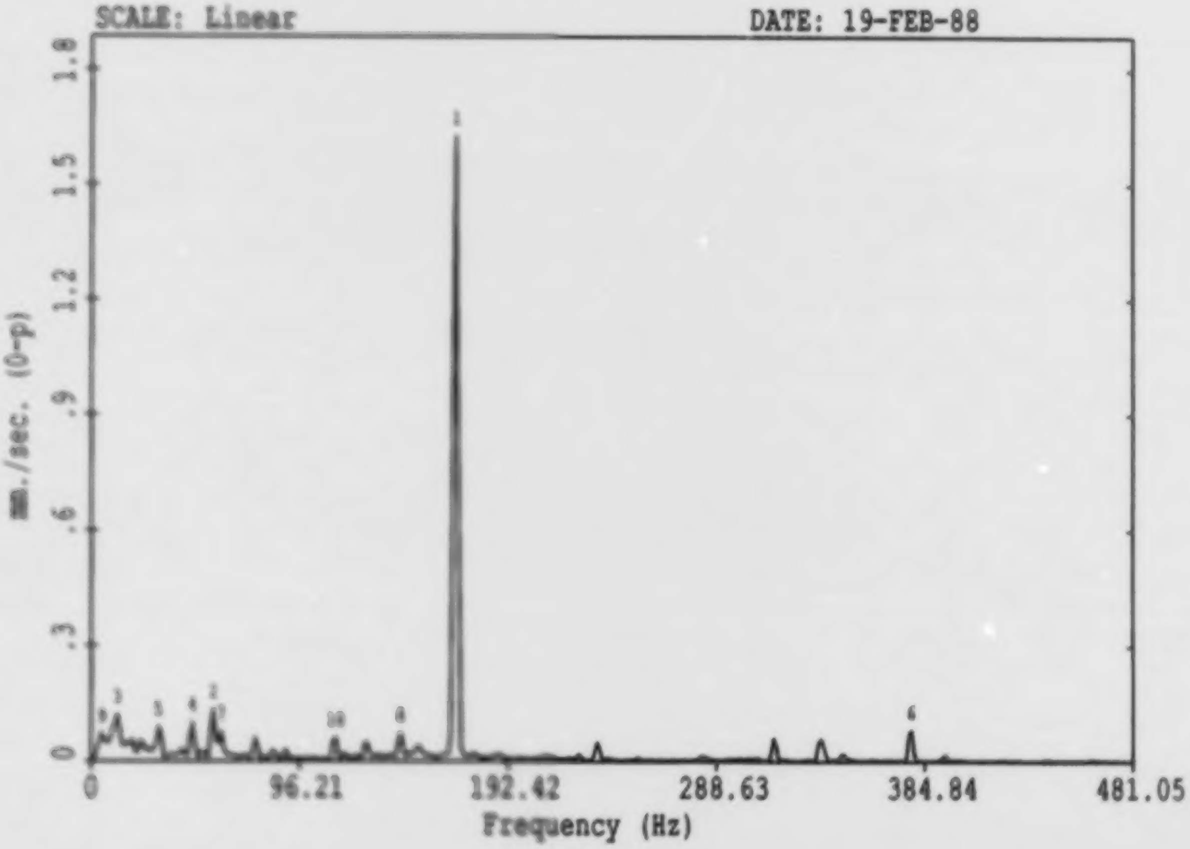


FIGURE E6

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	288.6	0.46
2	153.9	0.45
3	51.7	0.45
4	60.1	0.40
5	57.7	0.27
6	55.3	0.26
7	75.8	0.16
8	8.4	0.13
9	3.6	0.11
10	206.9	0.09

SCALE: Linear

DATE: 19-FEB-88

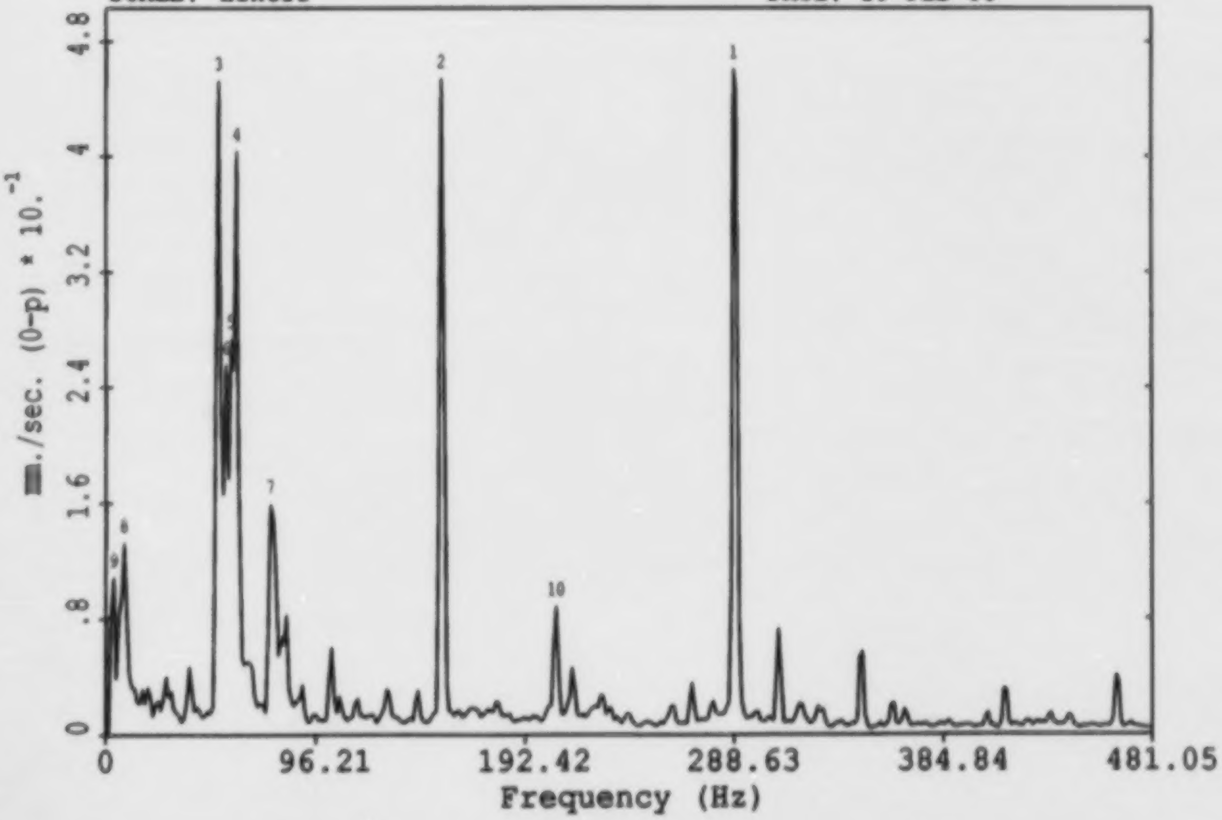


FIGURE E7

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.56
2	51.7	0.45
3	292.2	0.44
4	156.3	0.42
5	75.8	0.14
6	78.2	0.12
7	8.4	0.09
8	350.0	0.09
9	208.1	0.09
10	104.6	0.09

SCALE: Linear

DATE: 19-FEB-88

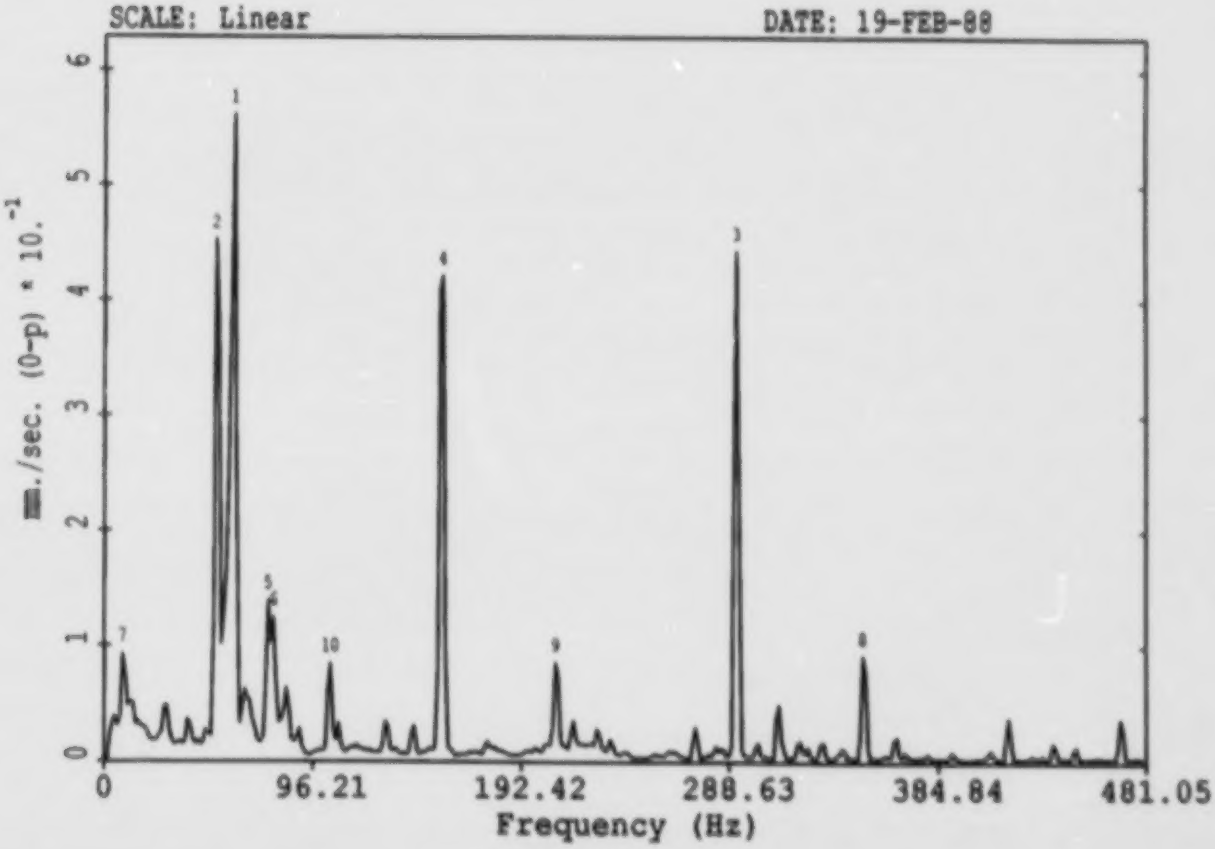


FIGURE E8

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 3.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	60.1	0.89
2	52.9	0.56
3	158.7	0.53
4	297.1	0.45
5	75.8	0.13
6	79.4	0.12
7	105.8	0.09
8	211.7	0.08
9	30.1	0.08
10	356.0	0.05

SCALE: Linear

DATE: 19-FEB-88

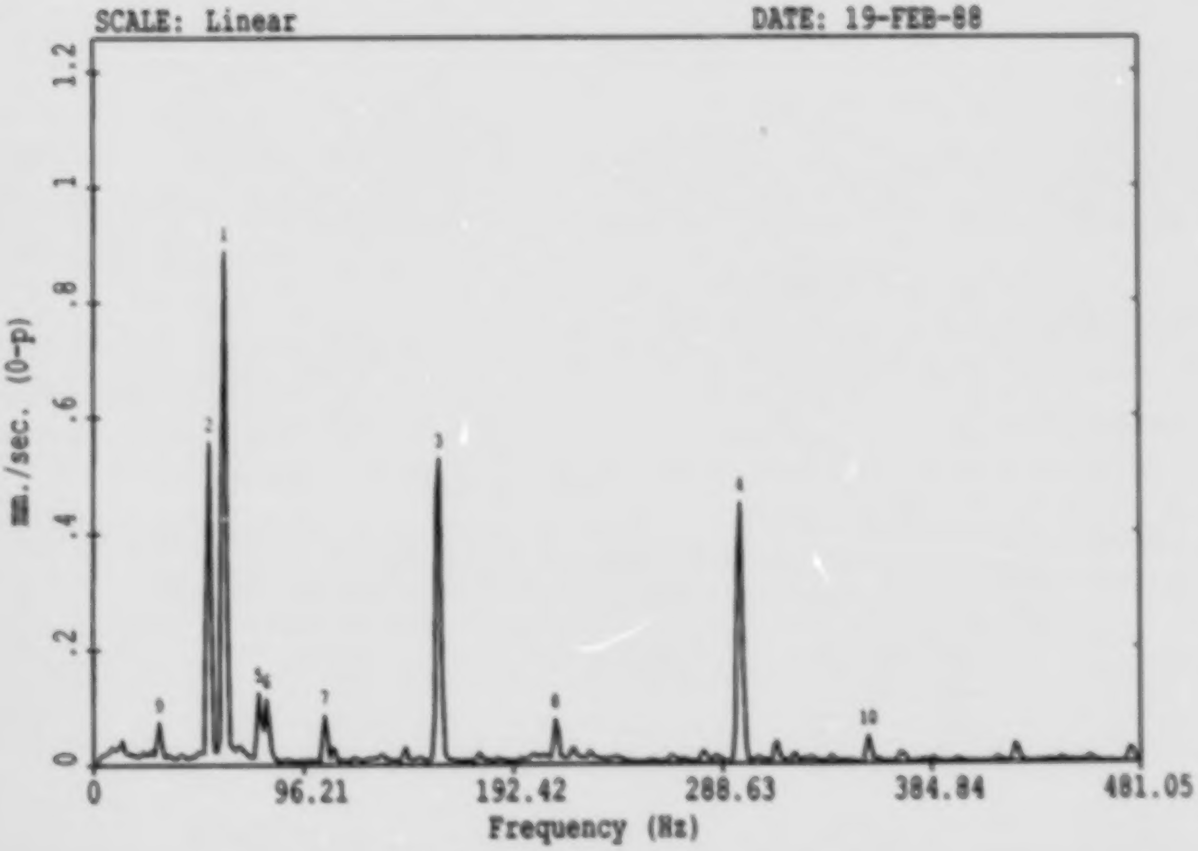


FIGURE E9

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	161.2	0.69
2	60.1	0.46
3	54.1	0.45
4	301.9	0.42
5	75.8	0.13
6	80.6	0.10
7	108.2	0.09
8	30.1	0.09
9	215.3	0.07
10	9.6	0.05

SCALE: Linear

DATE: 19-FEB-88

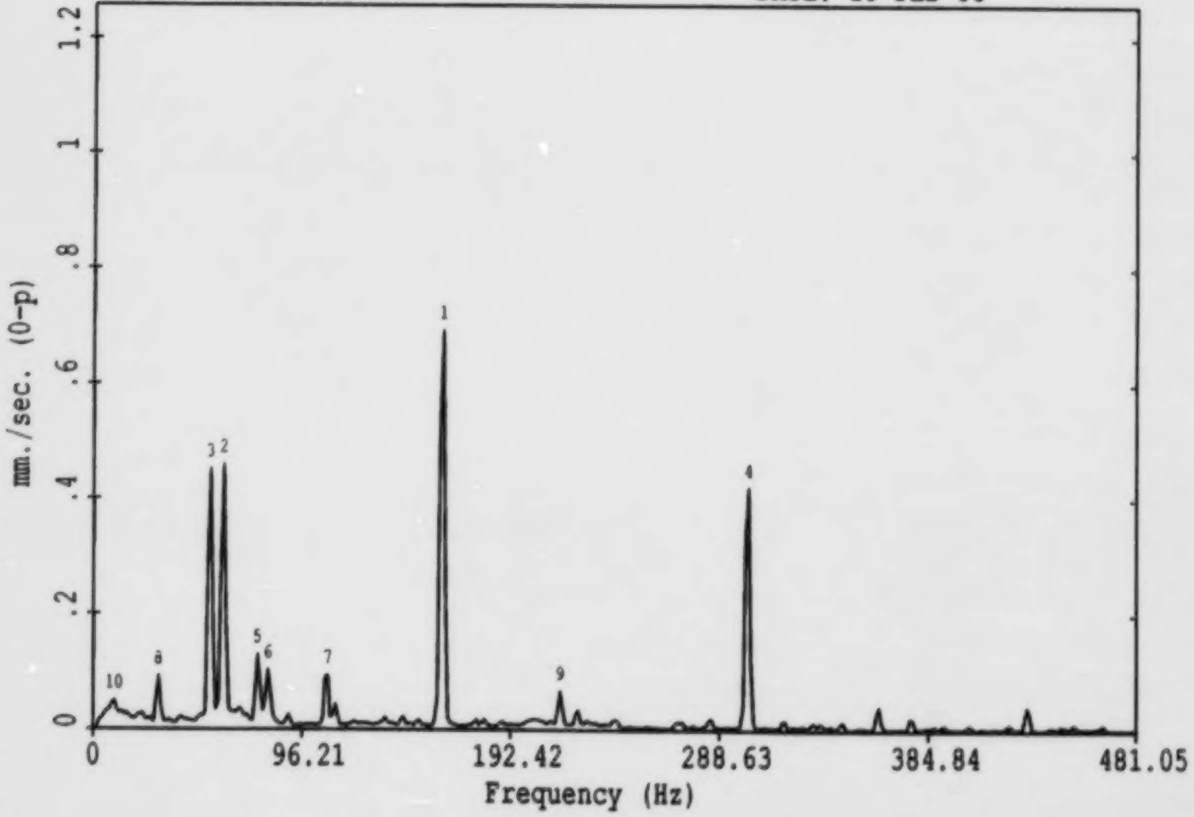


FIGURE E10

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	162.4	0.77
2	54.1	0.49
3	304.3	0.38
4	60.1	0.37
5	75.8	0.13
6	108.2	0.12
7	30.1	0.10
8	81.8	0.09
9	217.7	0.05
10	97.4	0.05

SCALE: Linear DATE: 19-FEB-88

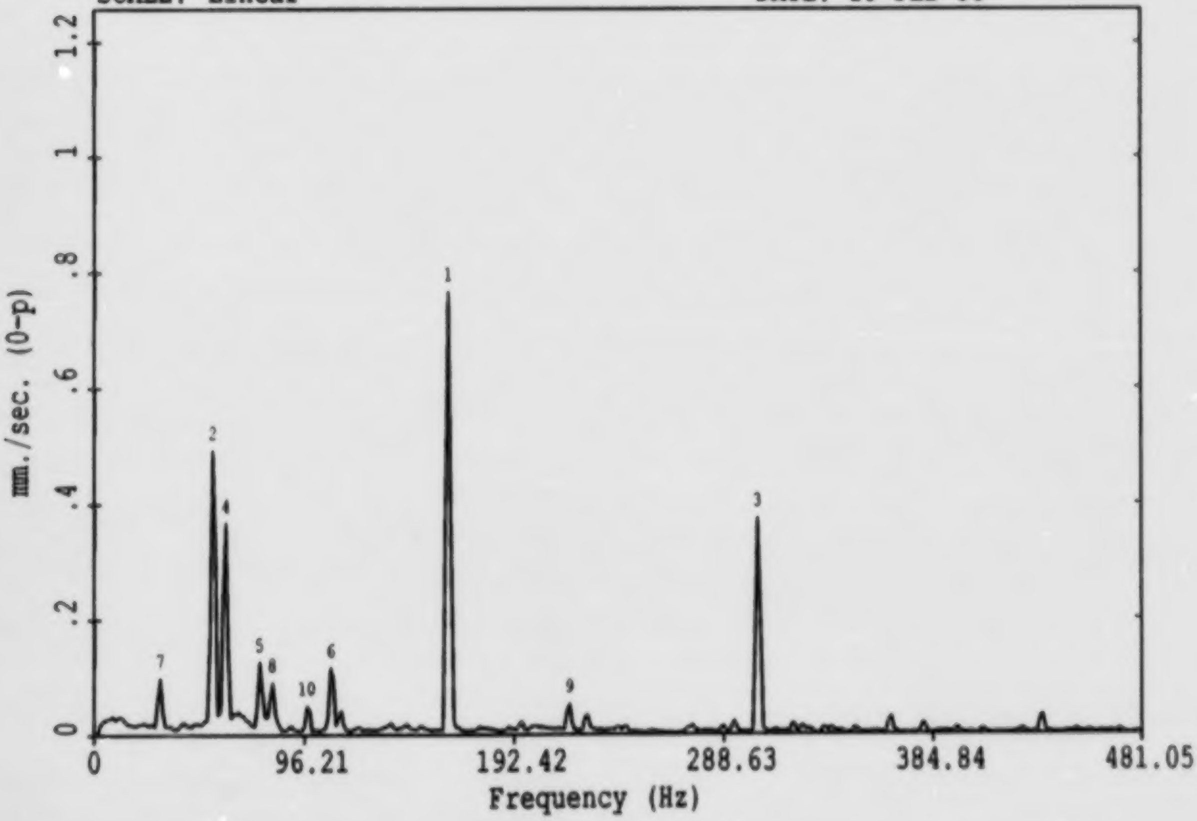


FIGURE E11

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : ACCESSORY GEARBOX CASING VELOCITY HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	168.4	0.65
2	56.5	0.62
3	60.1	0.33
4	113.0	0.25
5	315.1	0.23
6	30.1	0.13
7	75.8	0.12
8	378.8	0.12
9	84.2	0.08
10	13.2	0.06

SCALE: Linear

DATE: 19-FEB-88

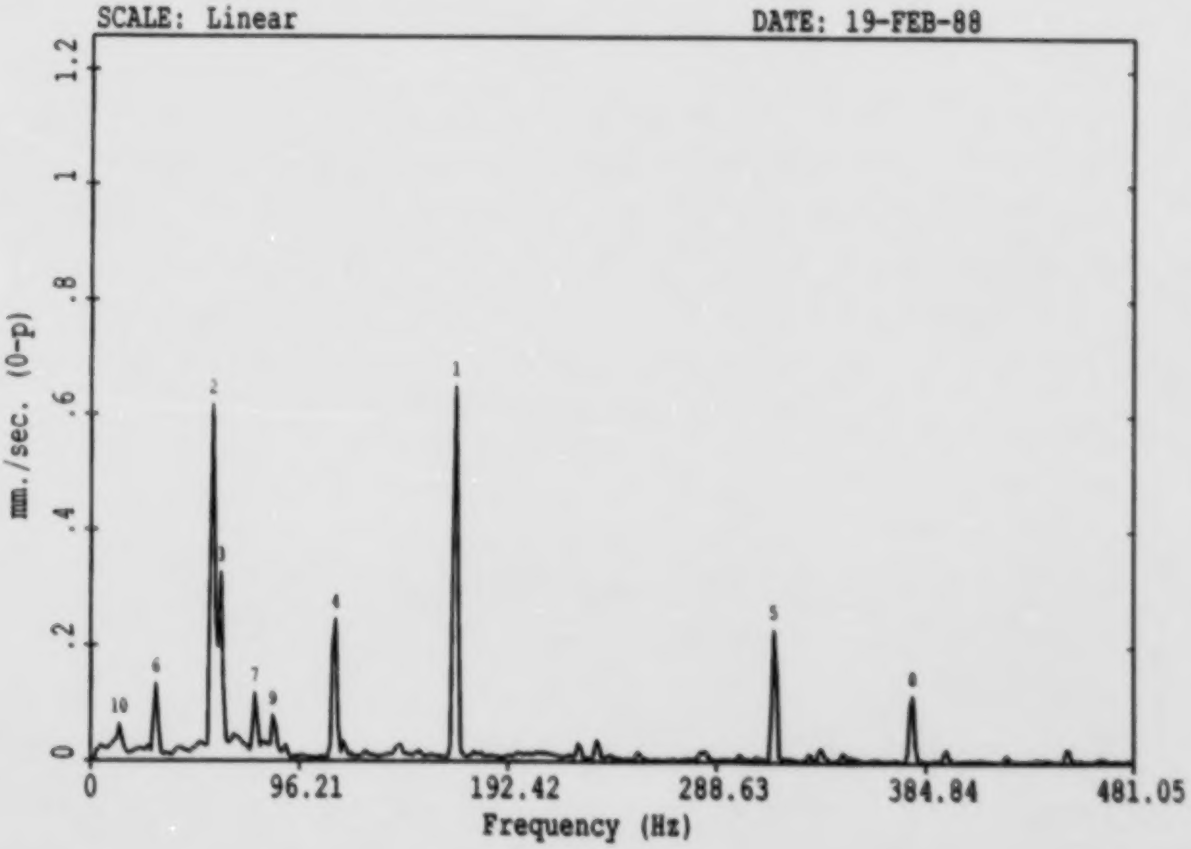


FIGURE E12

APPENDIX F

GAS PRODUCER DISPLACEMENT SPECTRA

TABLE F1
DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2 - GAS PRODUCER
FIGURE NUMBERS OF DISPLACEMENT SPECTRA

Measurement		FFT Spectrum Figure No. Load (MW)							
		0	1	1.5	2	3	4	5	6.8
Bearing No 1 Shaft Displacement	Vertical Direction	F1	F2	F3	F4	F5	F6	F7	F8
	Horizontal Direction	F9	F10	F11	F12	F13	F14	F15	F16
Bearing No 2 Shaft Displacement	Vertical Direction	F17	F18	F19	F20	F21	F22	F23	F24
	Horizontal Direction	F25	F26	F27	F28	F29	F30	F31	F32
Bearing No 3 Shaft Displacement	Vertical Direction	F33	F34	F35	F36	F37	F38	F39	F40
	Horizontal Direction	F41	F42	F43	F44	F45	F46	F47	F48

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	147.9	8.80
2	295.8	2.64
3	443.8	0.45
4	95.0	0.35
5	143.1	0.27
6	72.2	0.24
7	48.1	0.22

SCALE: Linear

DATE: 19-FEB-88

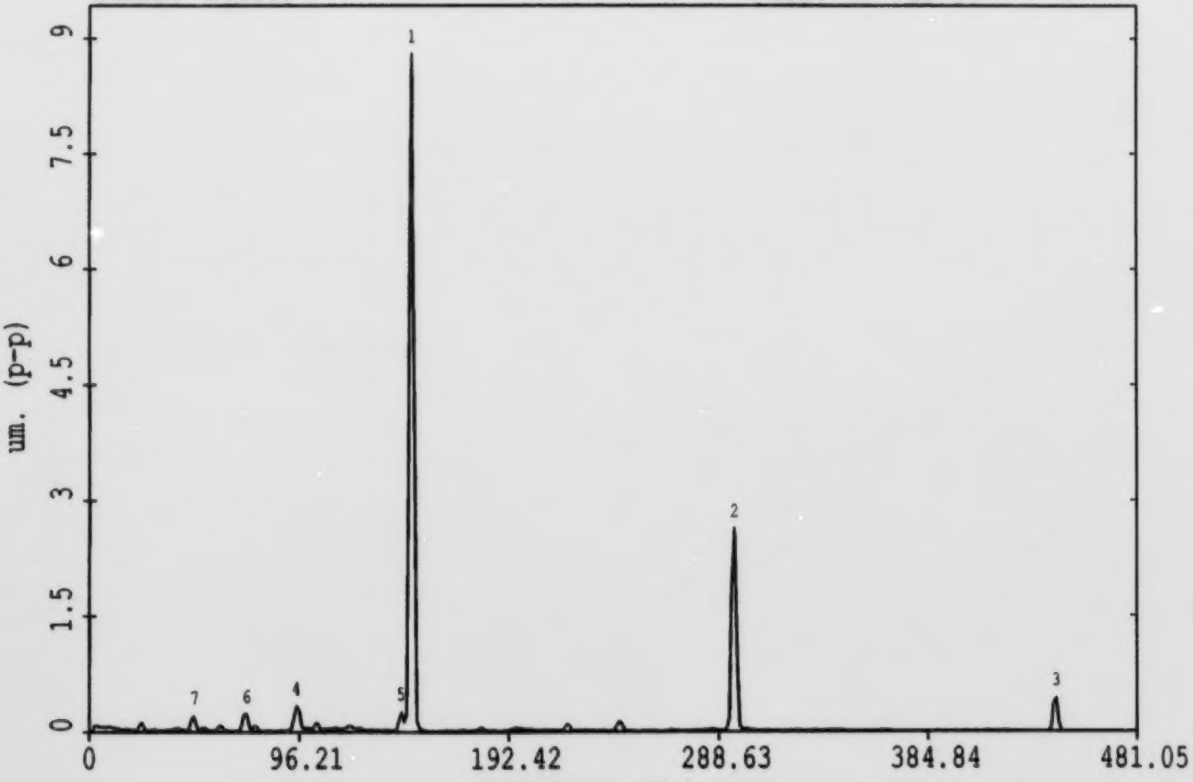


FIGURE F1

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	152.7	9.11
2	305.5	2.22
3	97.4	1.13
4	248.9	0.55
5	457.0	0.41
6	55.3	0.21

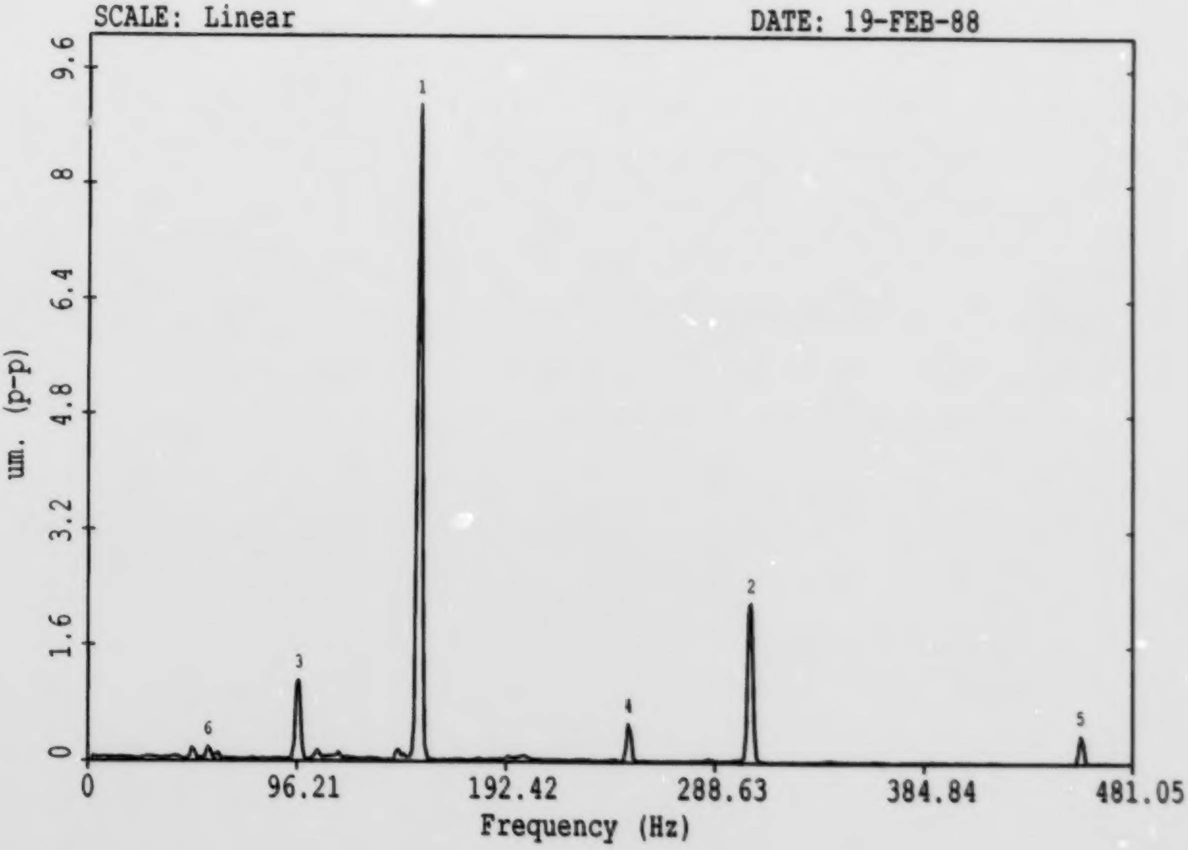


FIGURE F2

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	153.9	9.01
2	309.1	2.39
3	117.9	0.61
4	463.0	0.41
5	271.8	0.26
6	143.1	0.23
7	58.9	0.22

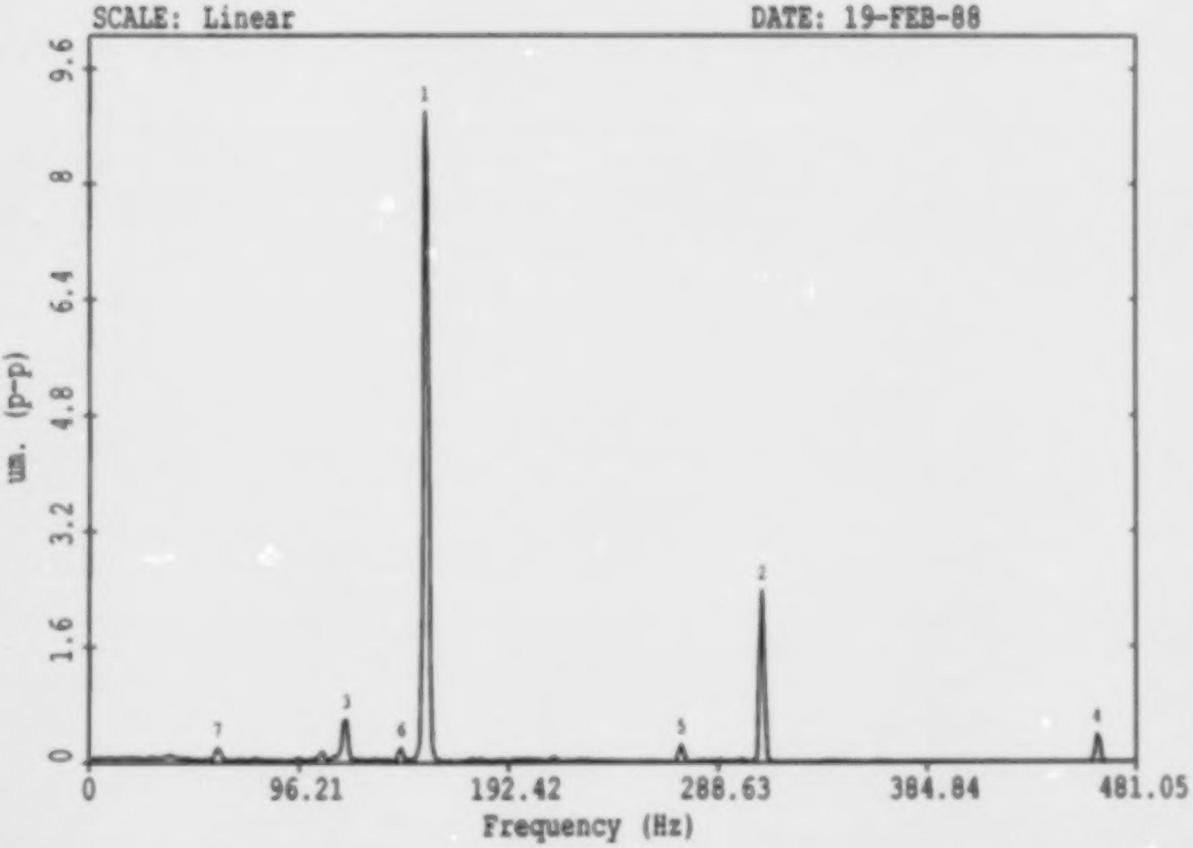
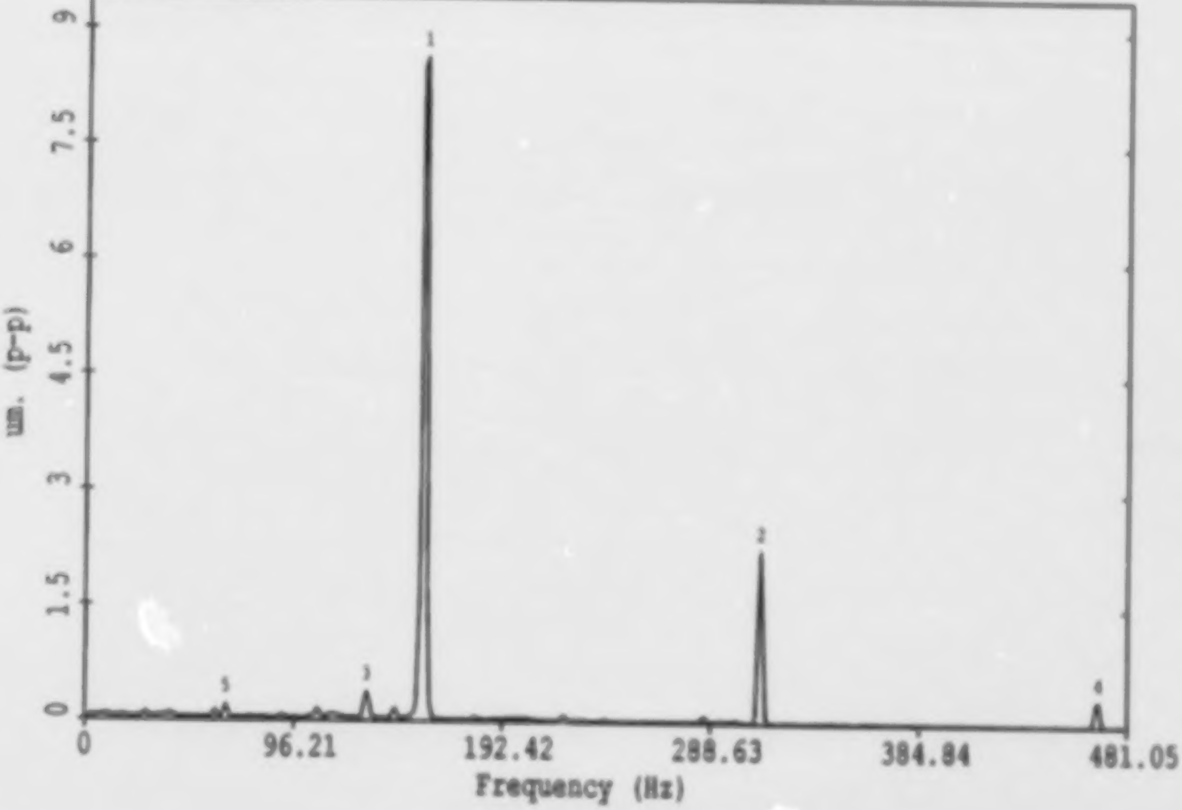


FIGURE F3

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	156.3	8.65
2	311.5	2.26
3	129.9	0.40
4	467.8	0.34
5	64.9	0.22



SCALE: Linear

DATE: 19-FEB-88

FIGURE F4

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	158.7	9.37
2	316.3	2.52
3	77.0	0.38
4	475.0	0.35
5	60.1	0.26
6	143.1	0.24
7	235.7	0.20
8	30.1	0.20

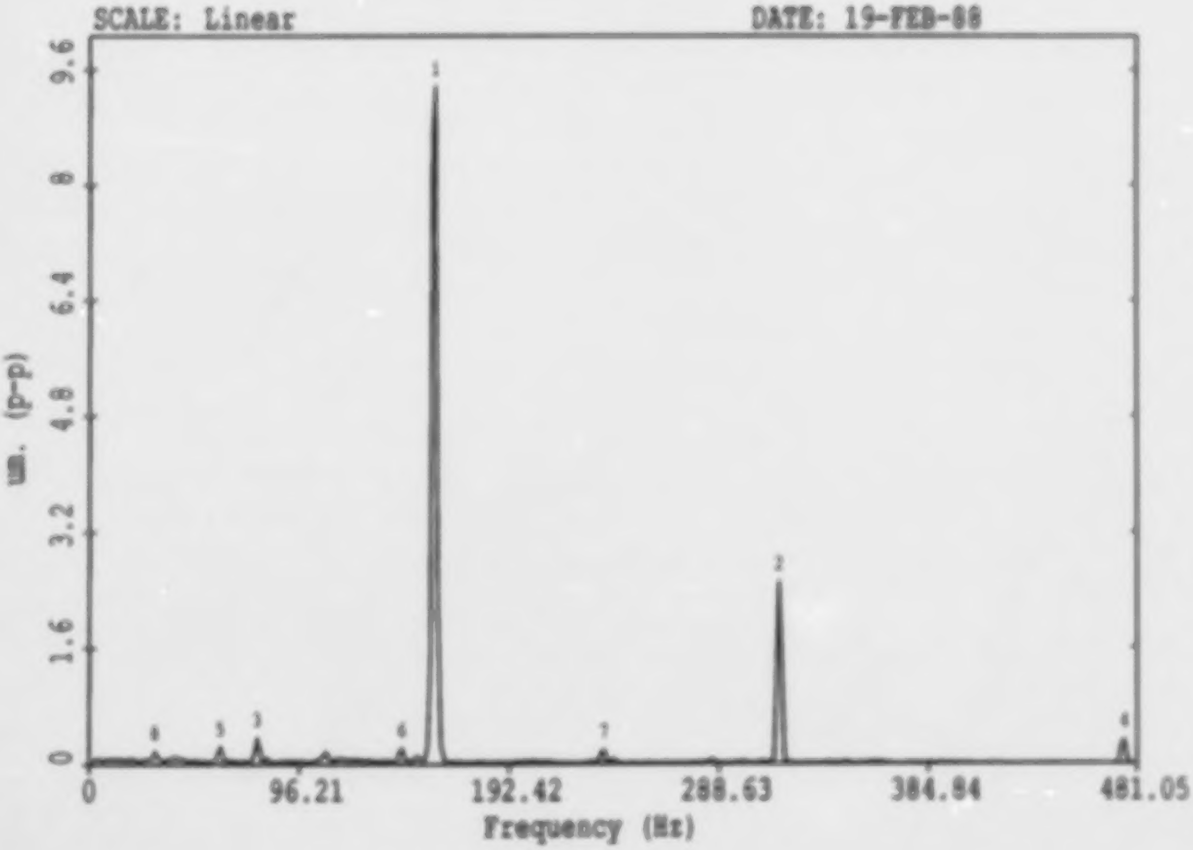
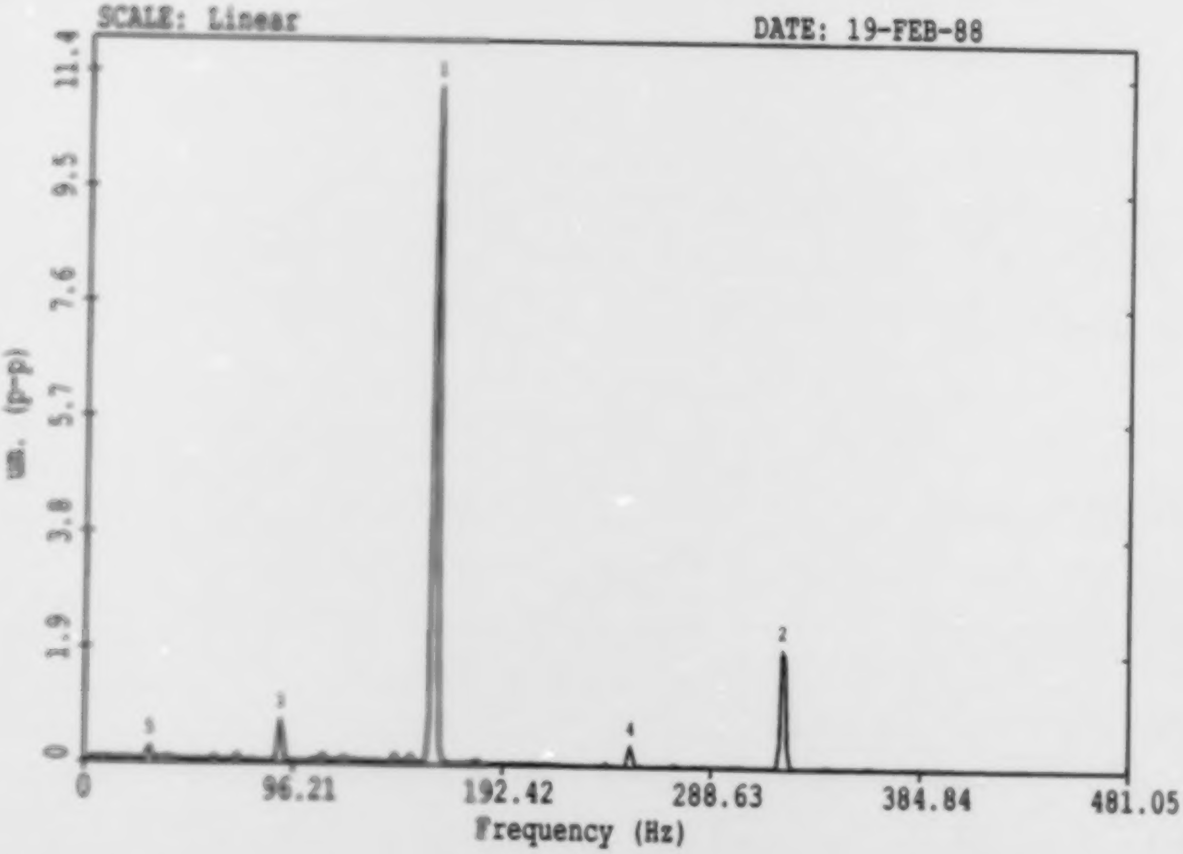


FIGURE F5

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	161.2	11.19
2	321.1	1.98
3	90.2	0.74
4	251.4	0.37
5	30.1	0.29



SCALE: Linear

DATE: 19-FEB-88

FIGURE F6

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	162.4	11.97
2	324.7	2.00
3	98.6	0.96
4	262.2	0.41
5	30.1	0.39

SCALE: Linear DATE: 19-FEB-88

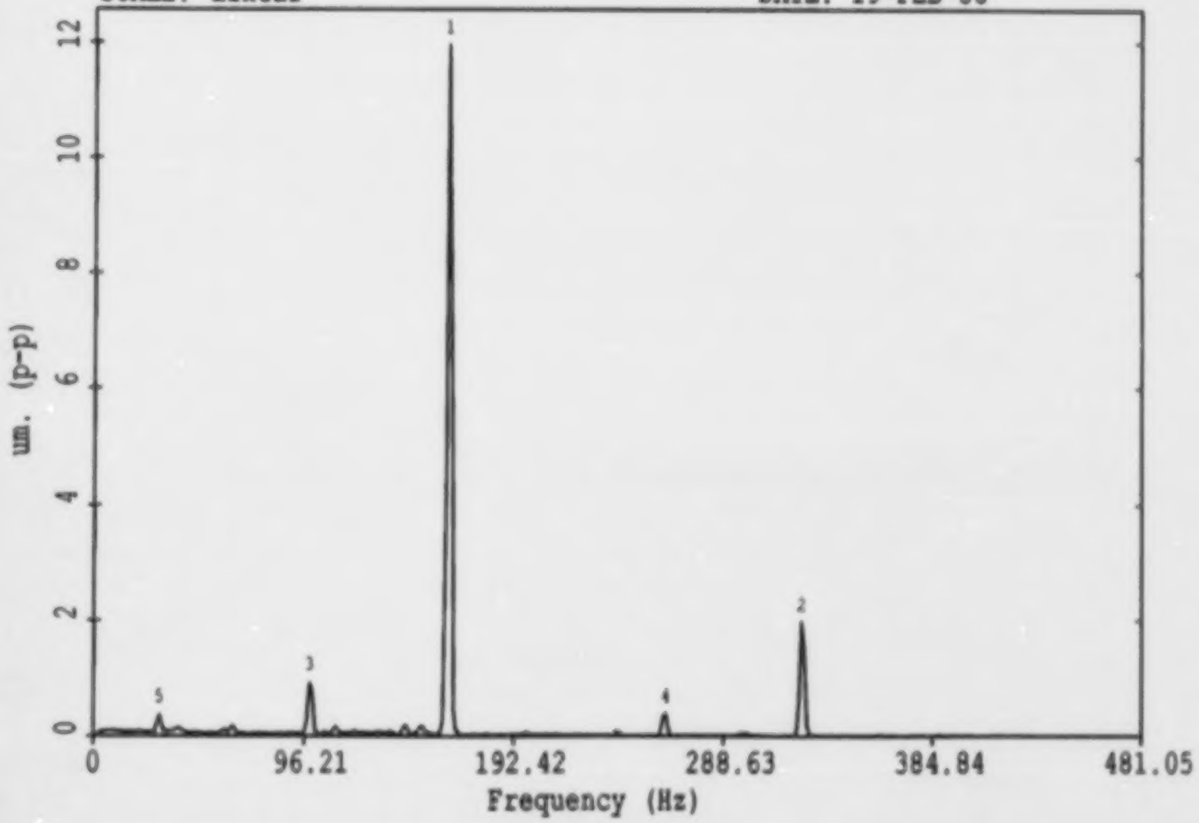
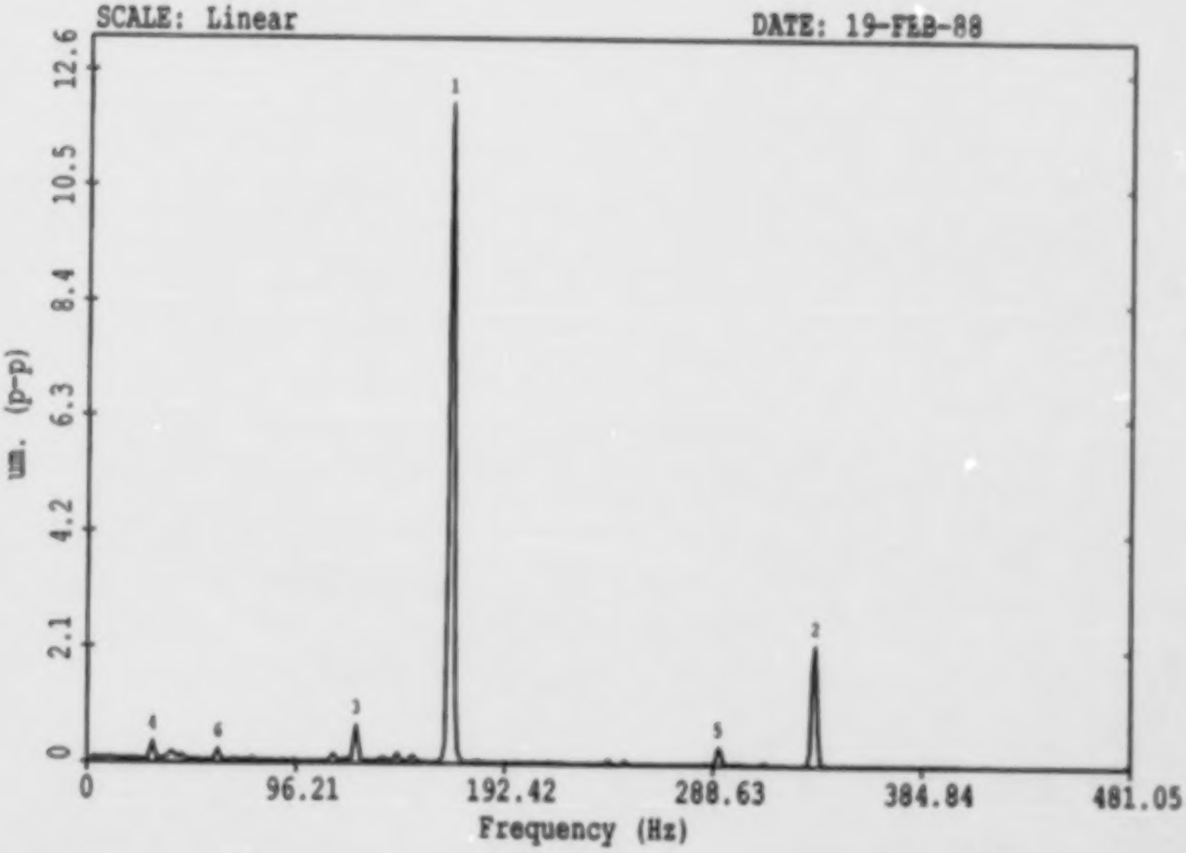


FIGURE F7

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	167.2	12.02
2	335.5	2.21
3	123.9	0.69
4	30.1	0.39
5	291.0	0.34
6	60.1	0.27


SCALE: Linear

DATE: 19-FEB-88

FIGURE F8

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	147.9	7.70
2	295.8	1.96
3	443.8	0.45
4	95.0	0.43
5	71.0	0.33
6	48.1	0.28
7	75.8	0.19

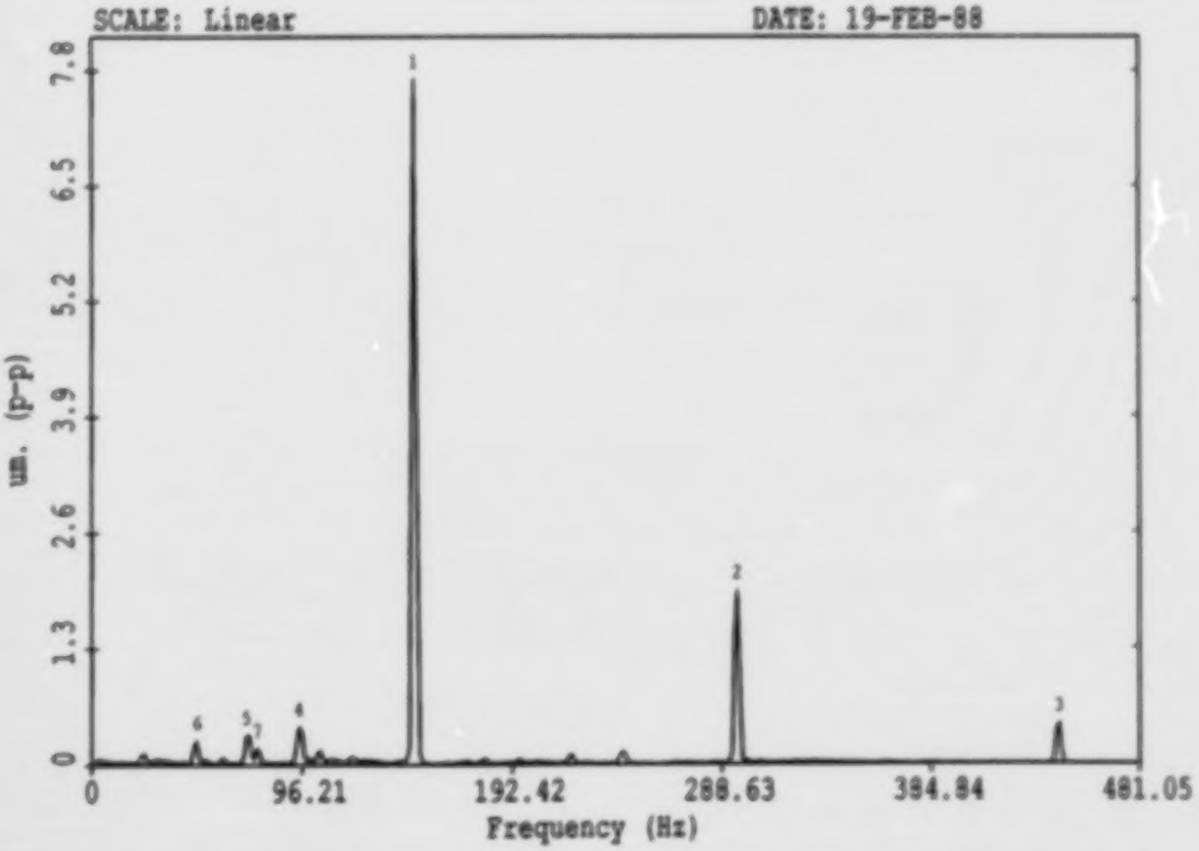


FIGURE F9

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	152.7	9.44
2	305.5	1.93
3	97.4	1.54
4	248.9	0.49
5	457.0	0.45
6	75.8	0.31
7	48.1	0.29
8	55.3	0.21

SCALE: Linear DATE: 19-FEB-88

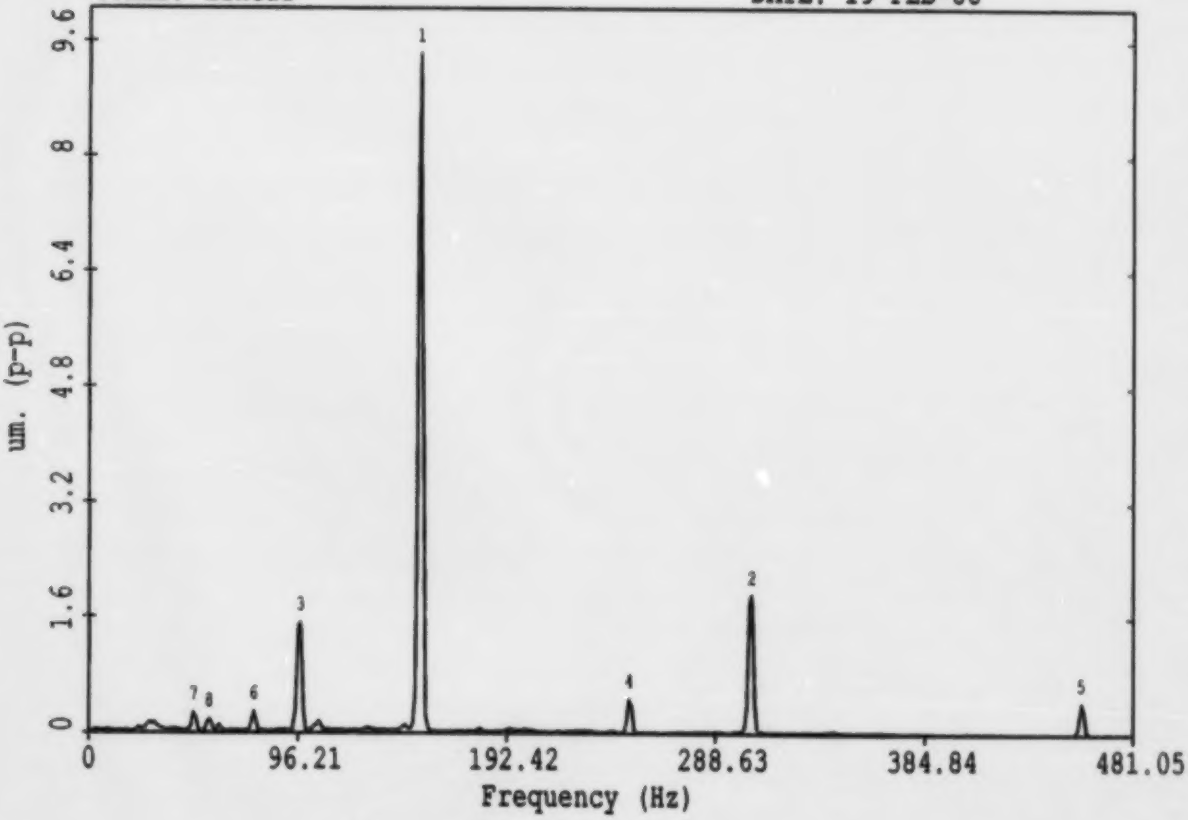


FIGURE F10

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	153.9	9.23
2	309.1	2.09
3	117.9	0.66
4	463.0	0.42
5	58.9	0.36
6	271.8	0.23
7	75.8	0.23
8	27.7	0.22

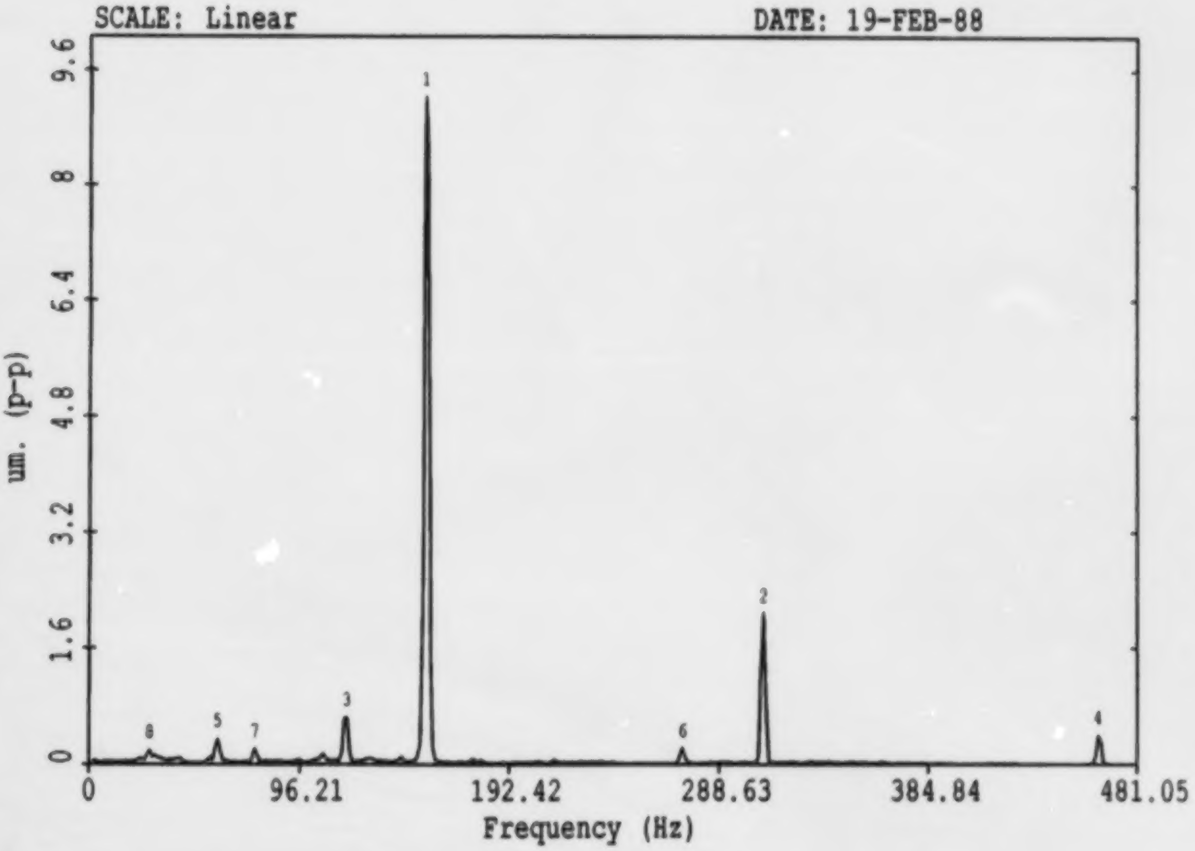


FIGURE F11

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	156.3	9.48
2	311.5	2.01
3	64.9	0.41
4	467.8	0.38
5	129.9	0.29
6	27.7	0.26
7	75.8	0.23

SCALE: Linear

DATE: 19-FEB-88

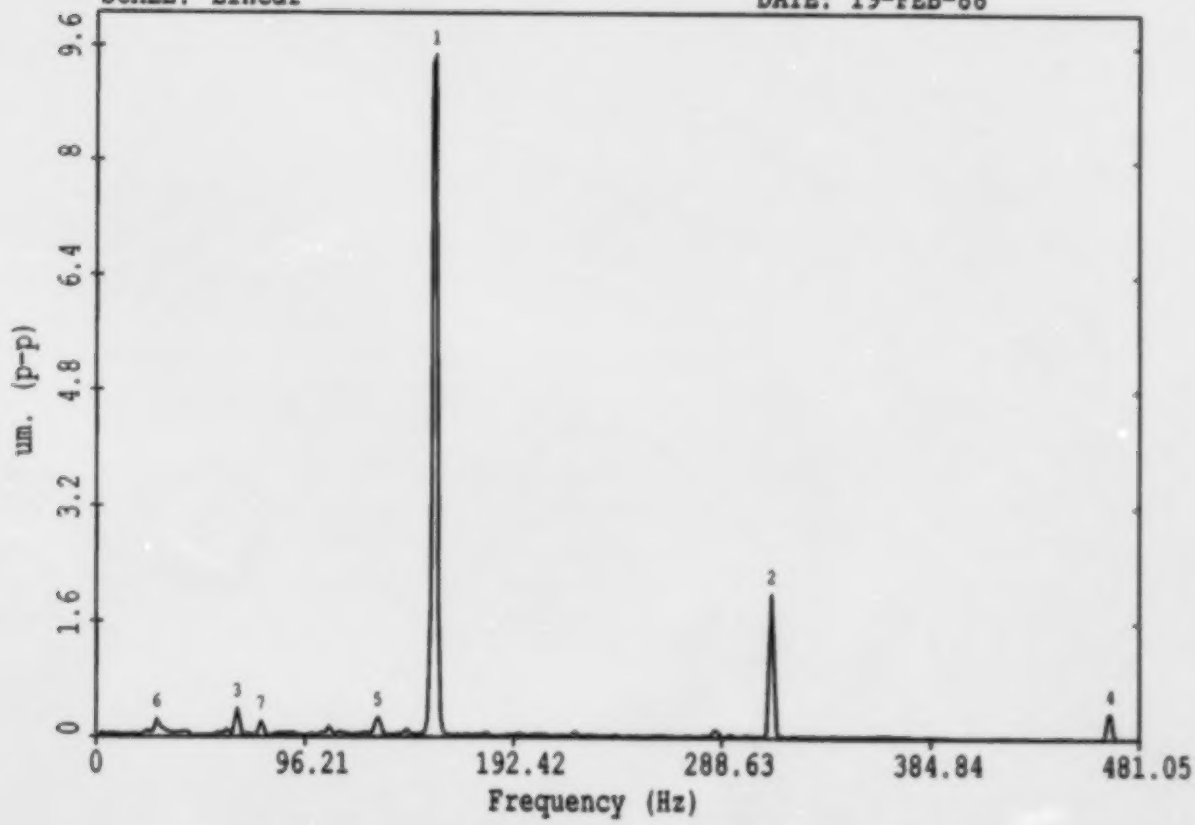


FIGURE F12

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	158.7	10.26
2	316.3	2.22
3	30.1	0.90
4	77.0	0.58
5	475.0	0.41

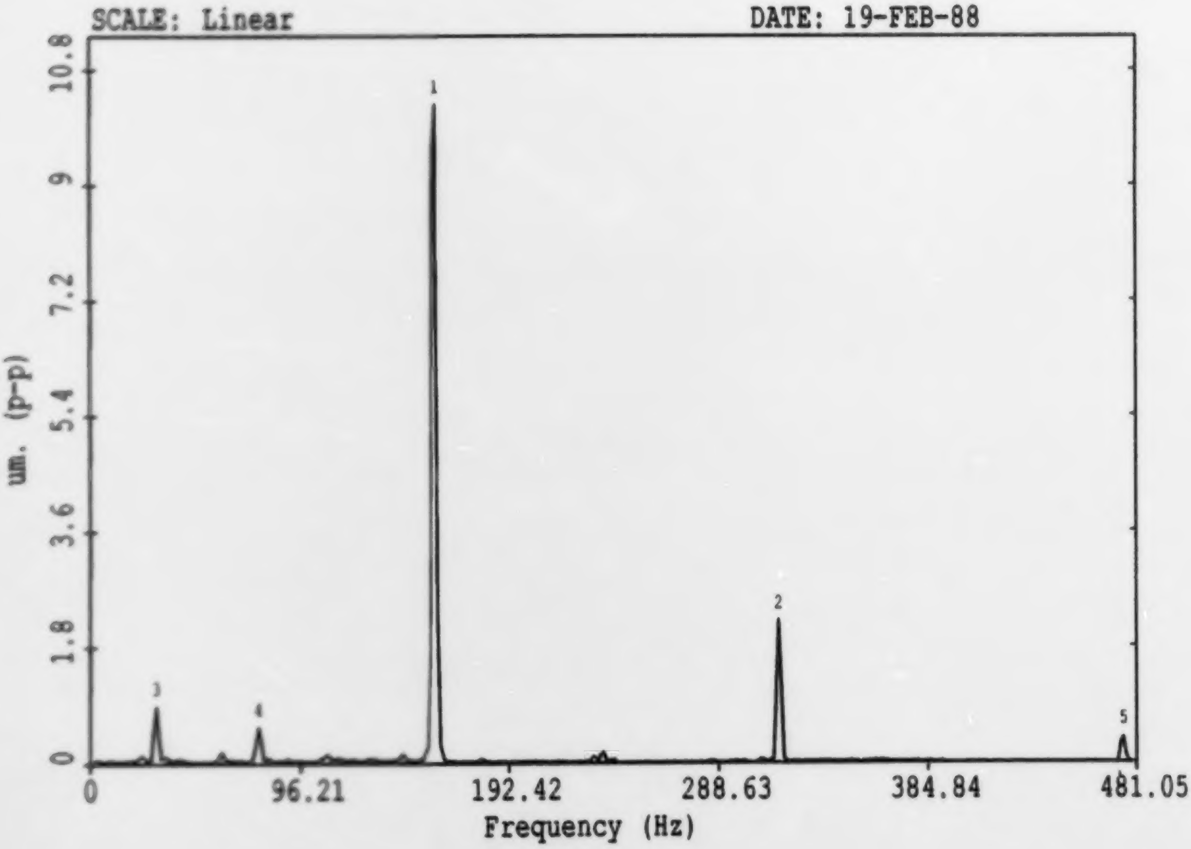


FIGURE F13

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	161.2	11.83
2	321.1	1.92
3	90.2	1.09
4	30.1	1.01
5	75.8	0.33
6	251.4	0.31

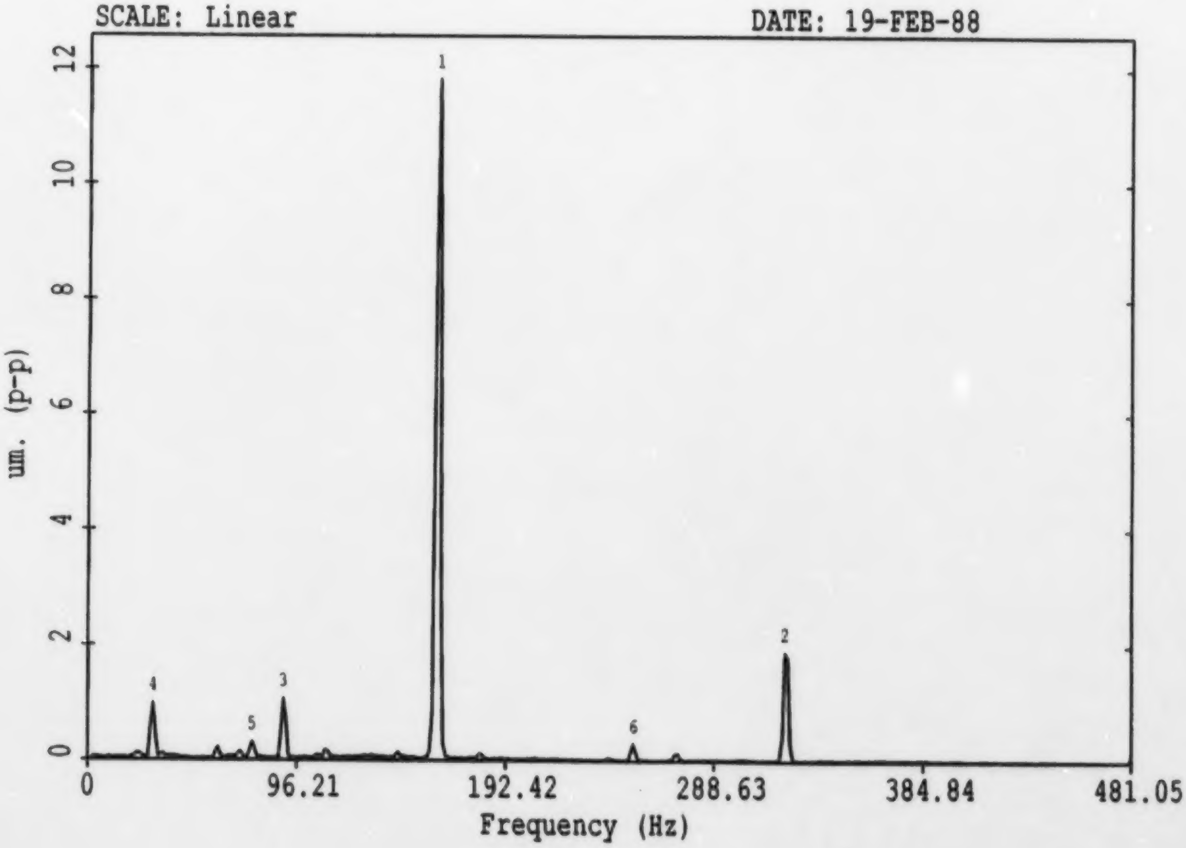


FIGURE F14

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	162.4	12.36
2	324.7	2.11
3	98.6	1.36
4	30.1	0.91
5	262.2	0.36
6	75.8	0.34

SCALE: Linear

DATE: 19-FEB-88

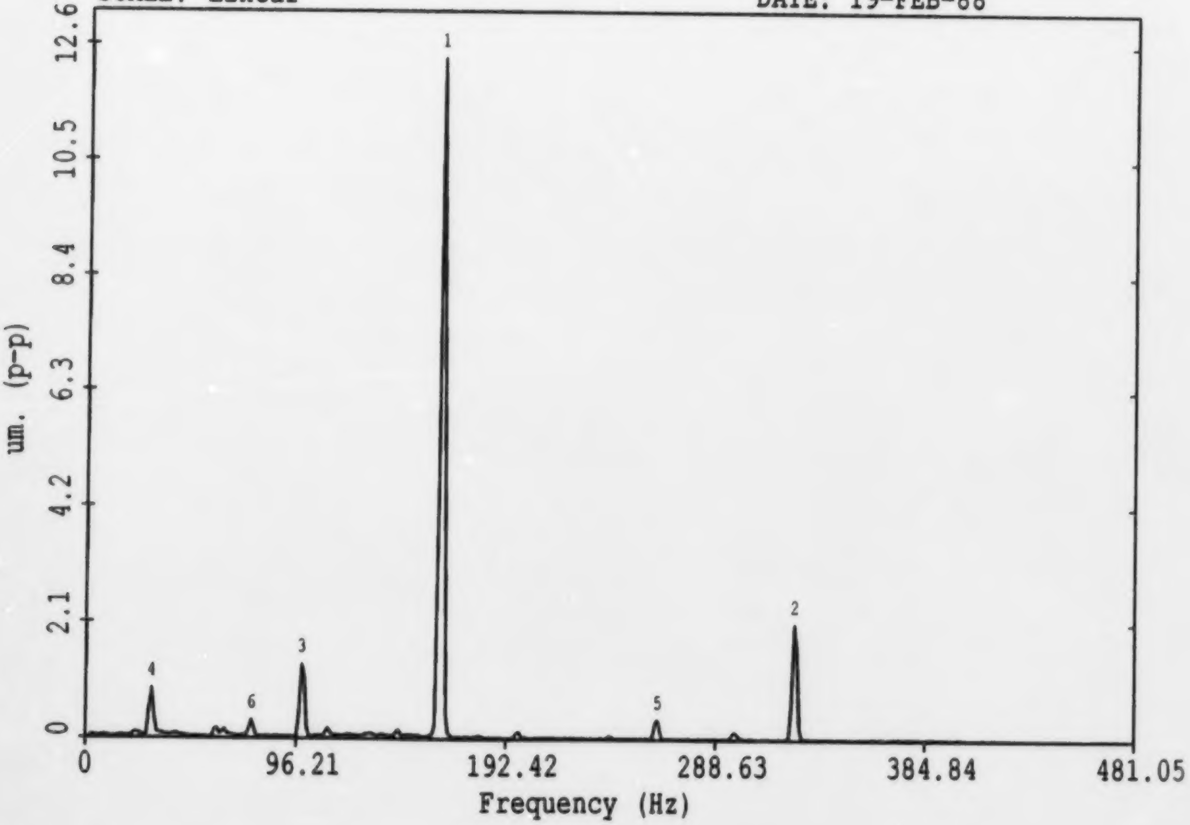


FIGURE F15

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #1 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	167.2	11.68
2	335.5	2.06
3	123.9	0.96
4	30.1	0.80
5	75.8	0.38
6	60.1	0.27
7	291.0	0.25

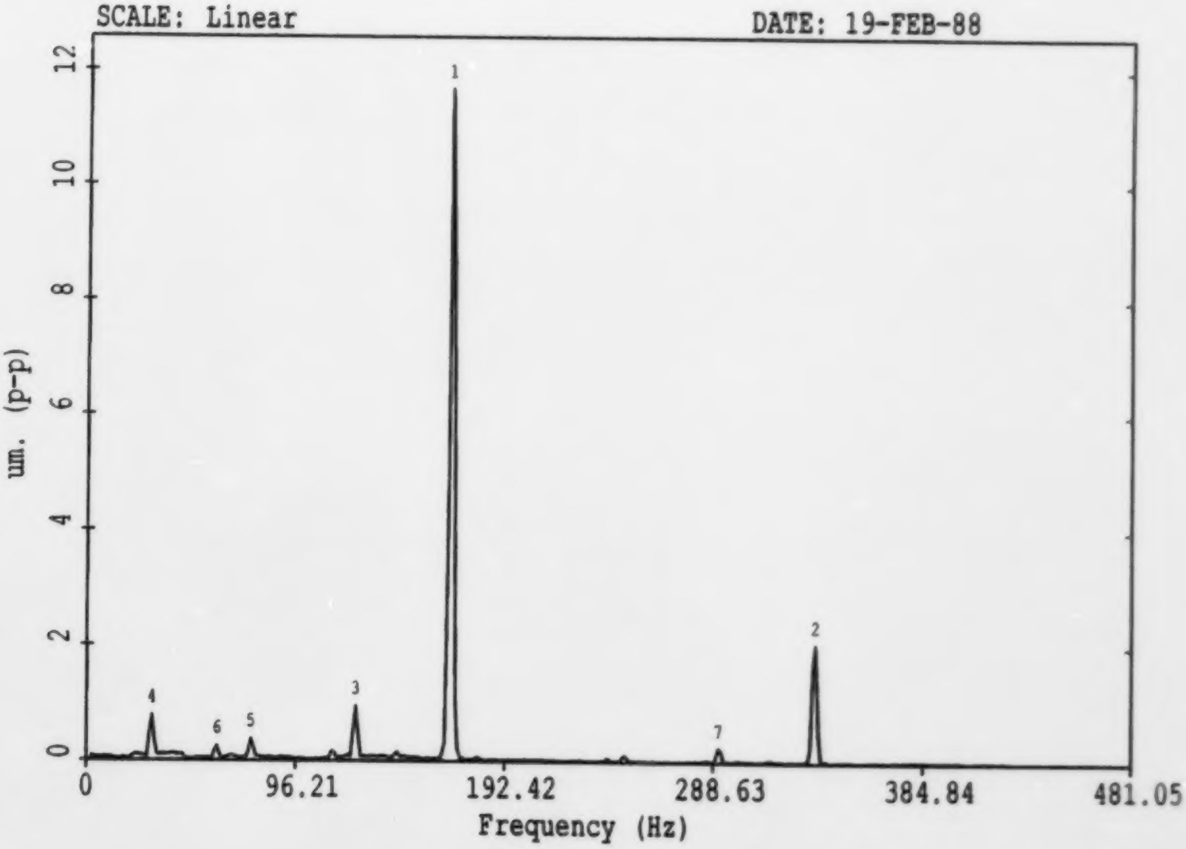


FIGURE F16

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	147.9	11.03
2	295.8	0.82
3	95.0	0.55
4	71.0	0.31
5	75.8	0.29
6	24.1	0.24

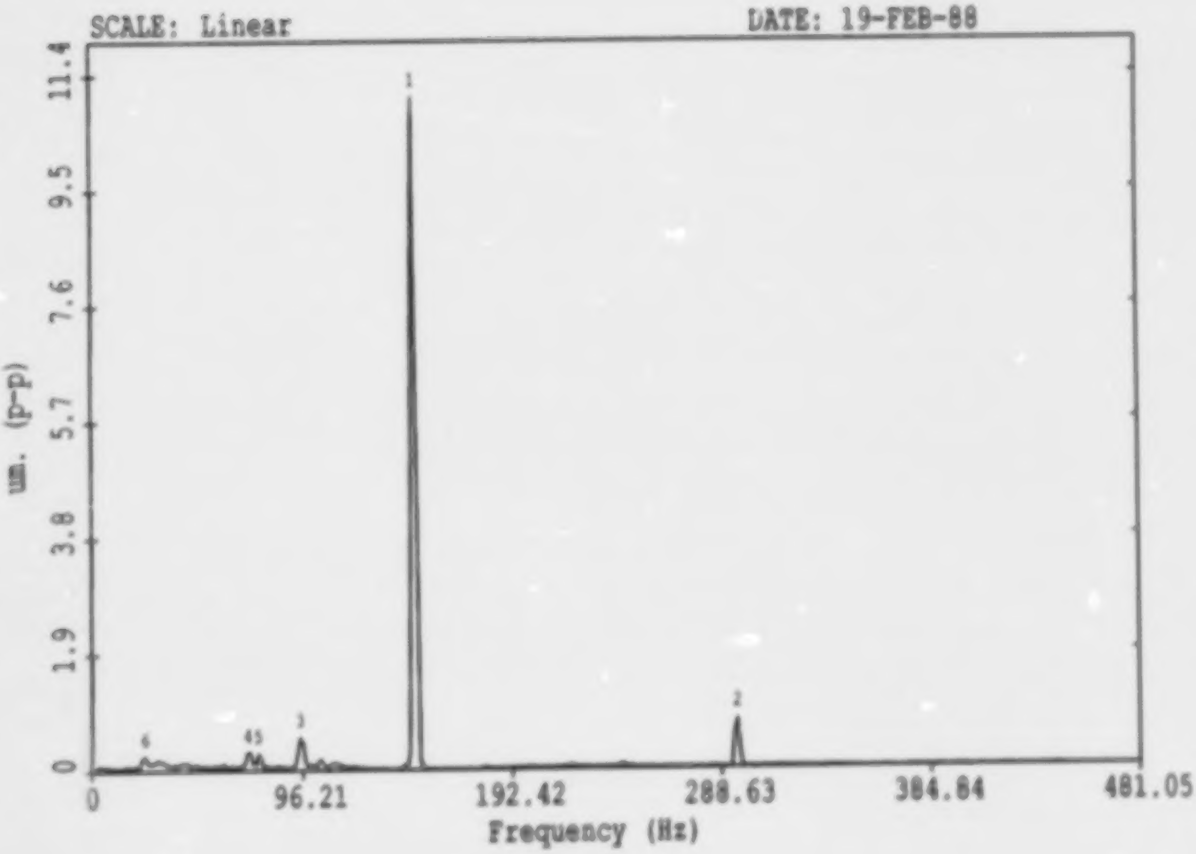


FIGURE F17

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	152.7	11.53
2	97.4	1.86
3	305.5	0.83
4	75.8	0.61
5	60.1	0.32
6	30.1	0.32
7	27.7	0.31
8	24.1	0.30
9	54.1	0.28
10	248.9	0.27

SCALE: Linear

DATE: 19-FEB-88

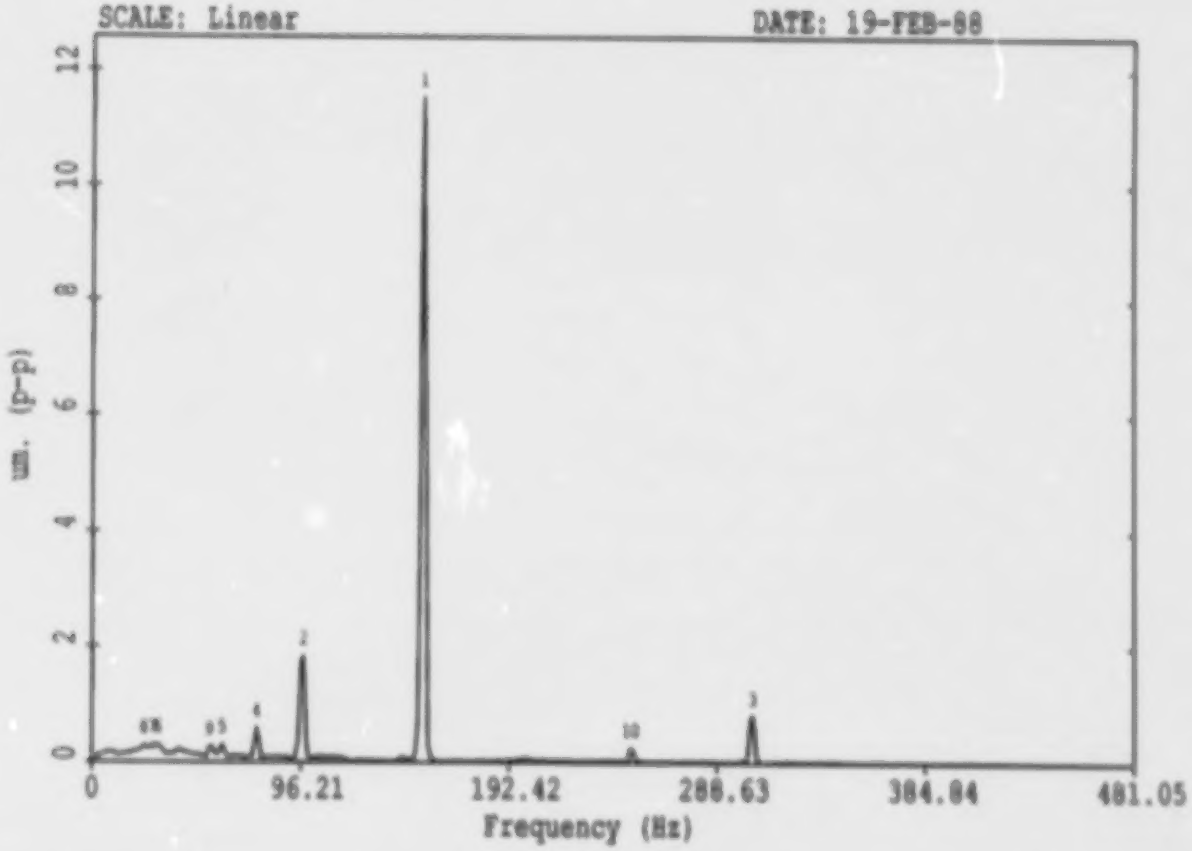


FIGURE F18

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	153.9	11.01
2	309.1	1.02
3	27.7	0.50
4	75.8	0.47
5	117.9	0.46
6	22.9	0.35
7	30.1	0.34
8	7.2	0.34
9	55.3	0.34
10	58.9	0.31

SCALE: Linear DATE: 19-FEB-88

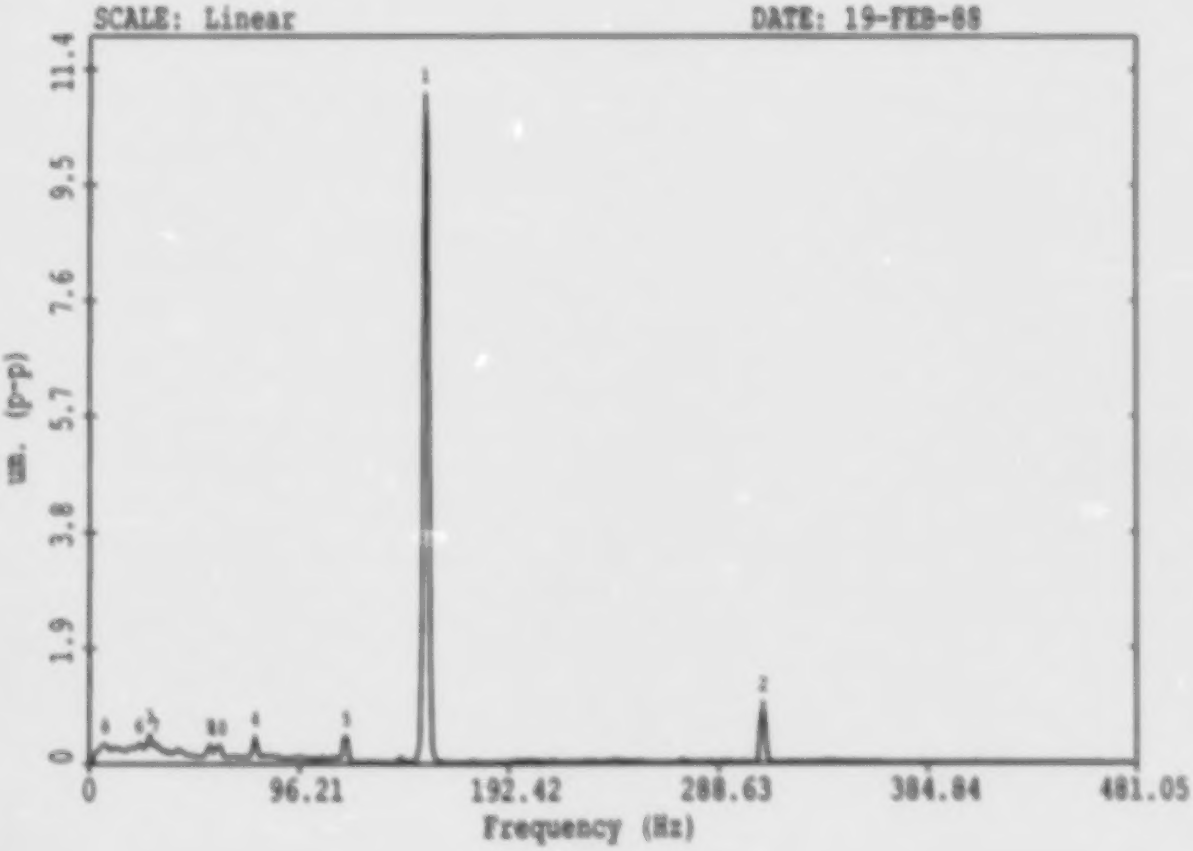


FIGURE F19

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	156.3	11.30
2	311.5	1.01
3	27.7	0.59
4	75.8	0.56
5	8.4	0.42
6	13.2	0.41
7	64.9	0.36
8	21.6	0.32
9	31.3	0.32
10	56.5	0.31

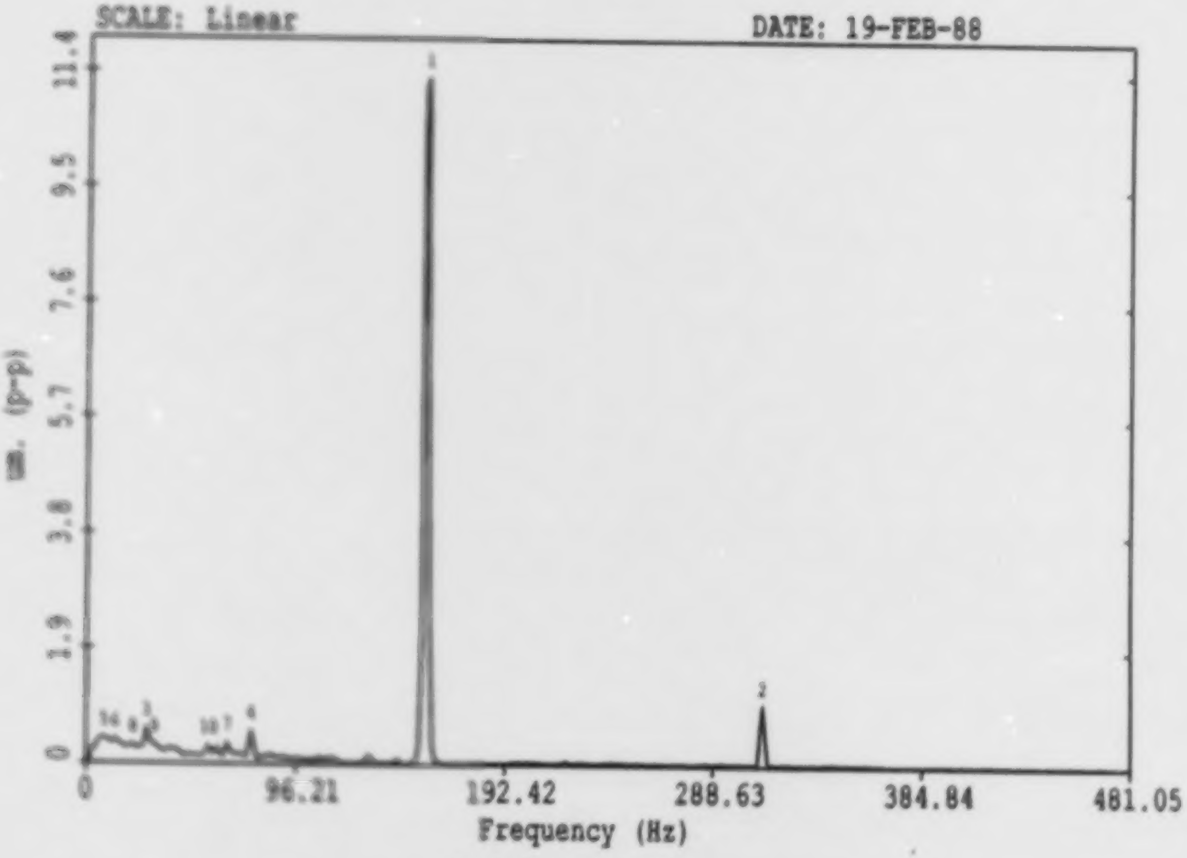


FIGURE F20

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	158.7	12.23
2	30.1	1.86
3	316.3	1.26
4	9.6	0.77
5	77.0	0.75
6	14.4	0.58
7	60.1	0.58
8	20.4	0.45
9	18.0	0.42
10	26.5	0.37

SCALE: Linear

DATE: 19-FEB-88

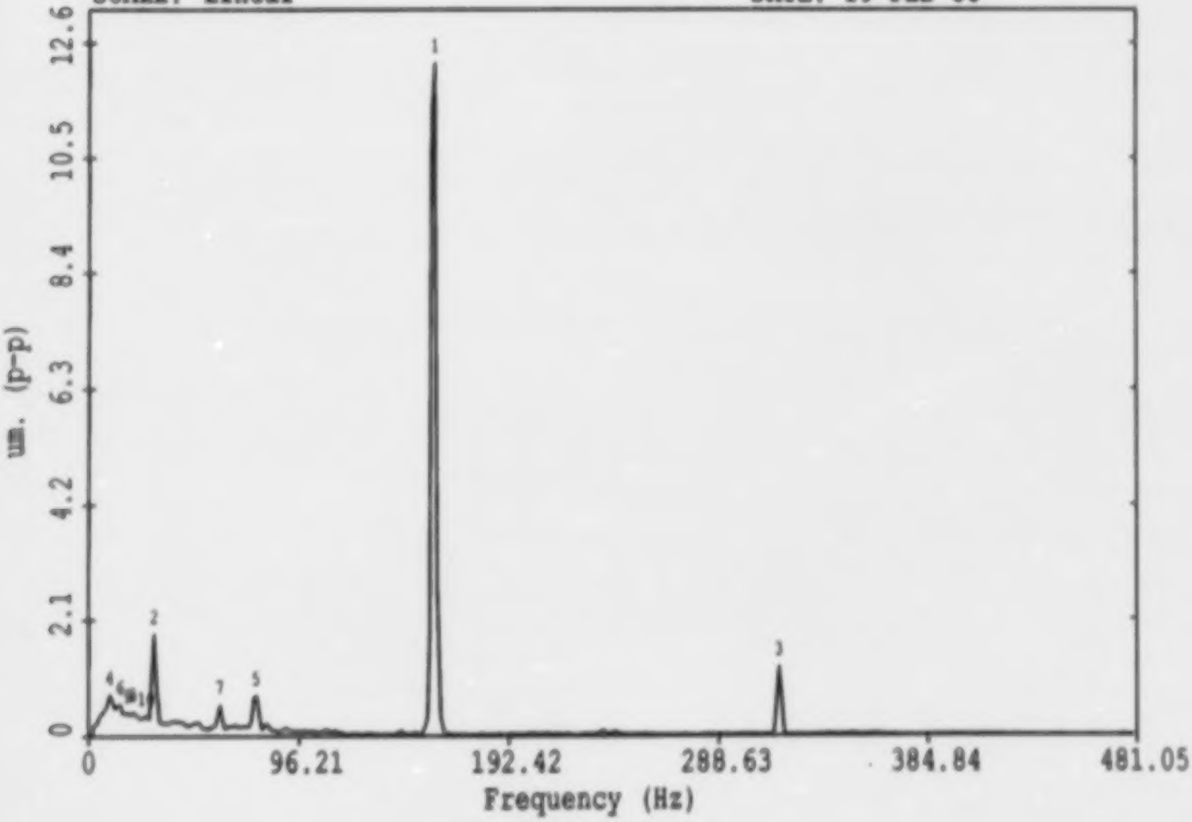


FIGURE F21

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	161.2	14.96
2	30.1	2.11
3	90.2	1.63
4	8.4	1.14
5	321.1	1.07
6	75.8	0.87
7	14.4	0.69
8	60.1	0.56
9	19.2	0.54
10	21.6	0.47

SCALE: Linear

DATE: 19-FEB-88

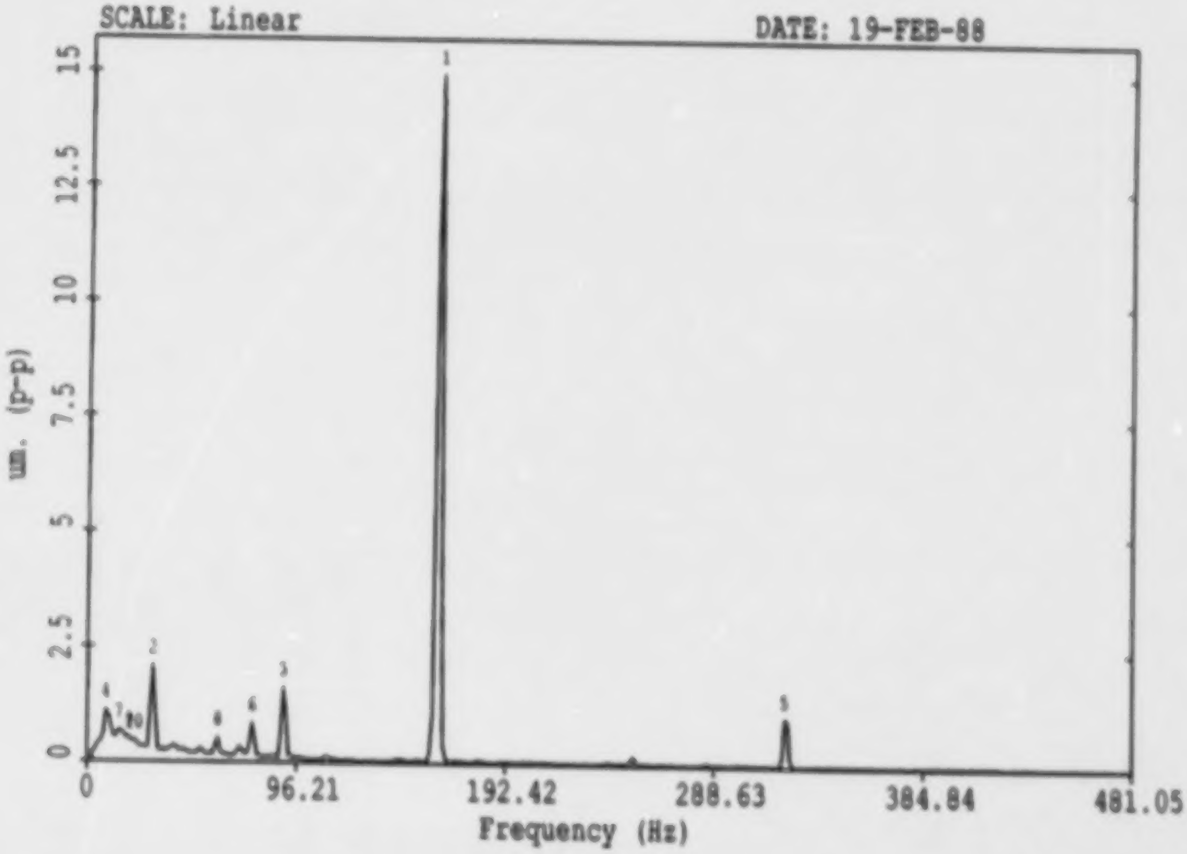


FIGURE F22

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	162.4	15.62
2	98.6	1.98
3	30.1	1.78
4	324.7	1.00
5	75.8	0.85
6	8.4	0.75
7	60.1	0.57
8	12.0	0.56
9	18.0	0.53
10	14.4	0.49

SCALE: Linear

DATE: 19-FEB-88

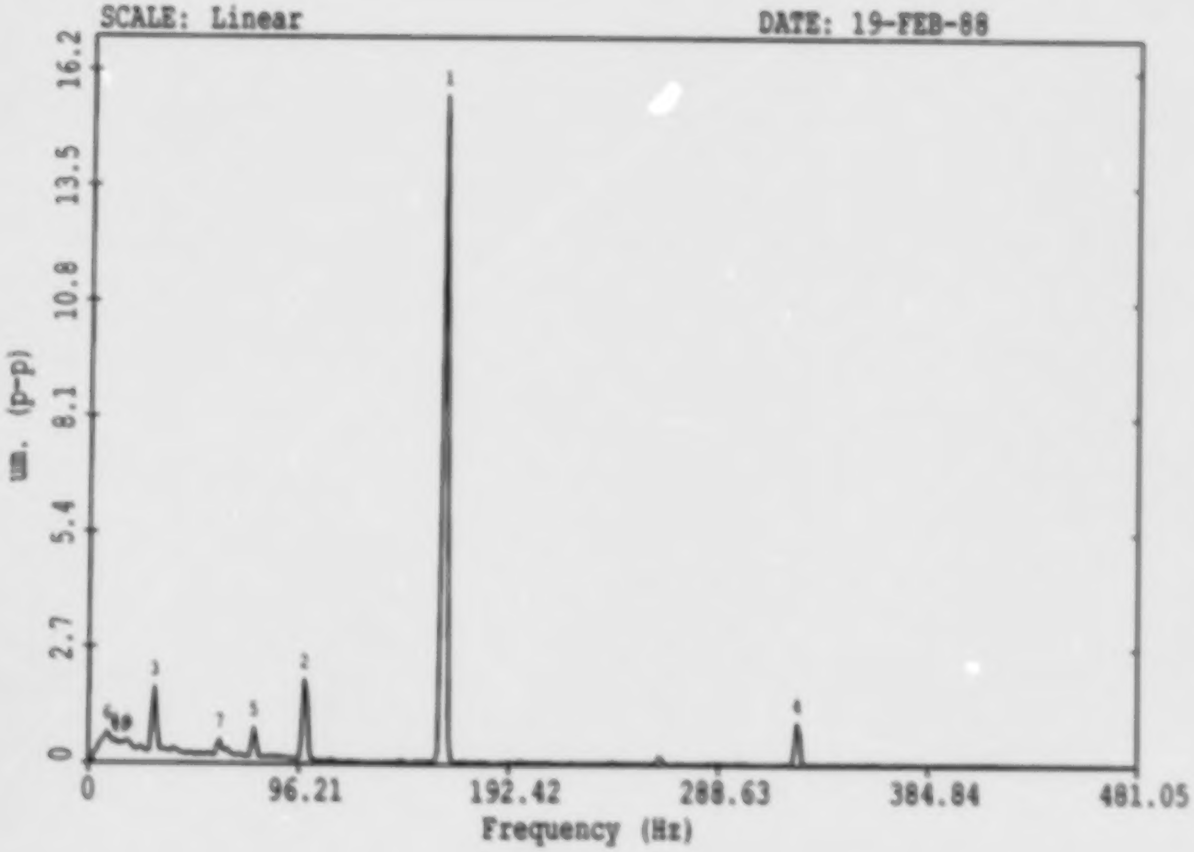


FIGURE F23

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	167.2	15.71
2	30.1	1.55
3	75.8	0.98
4	123.9	0.76
5	335.5	0.74
6	60.1	0.60
7	13.2	0.38
8	8.4	0.35
9	20.4	0.34
10	34.9	0.34

SCALE: Linear

DATE: 19-FEB-88

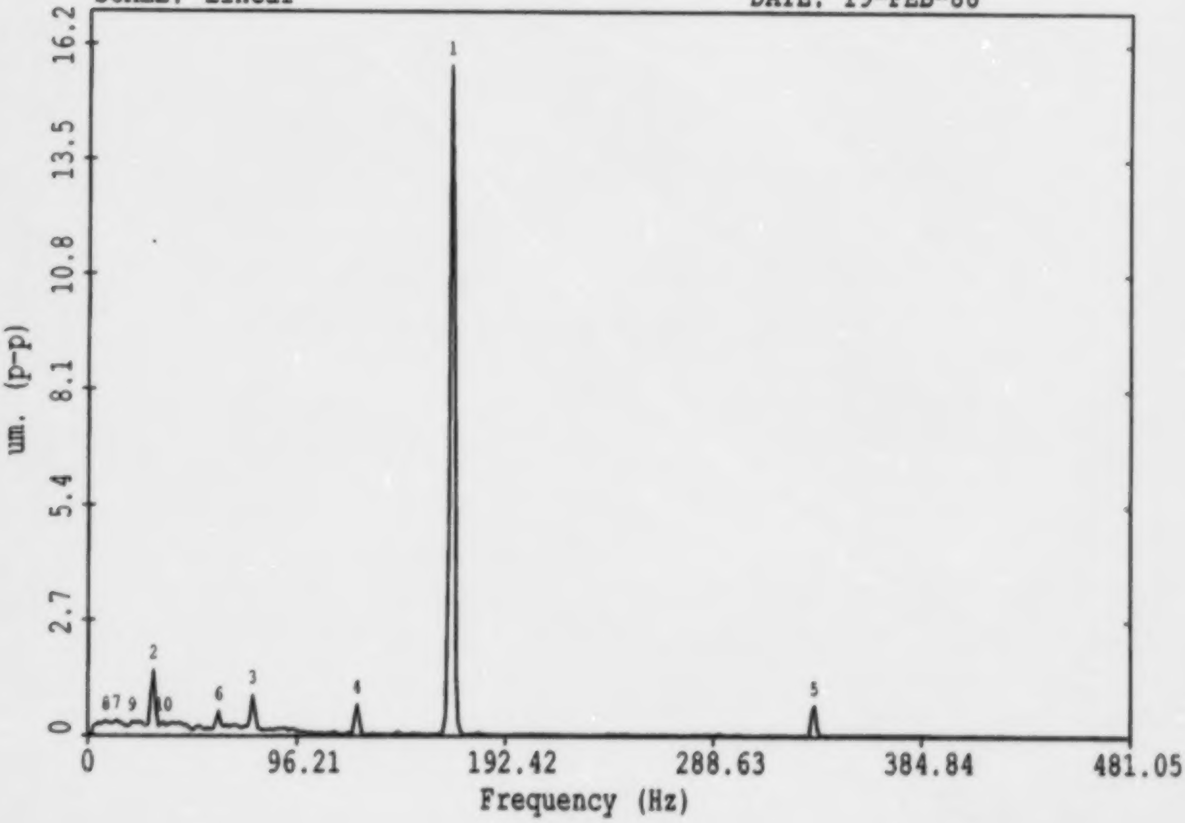


FIGURE F24

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	147.9	8.54
2	295.8	0.76
3	95.0	0.51
4	75.8	0.43
5	24.1	0.35
6	71.0	0.22

SCALE: Linear

DATE: 19-FEB-88

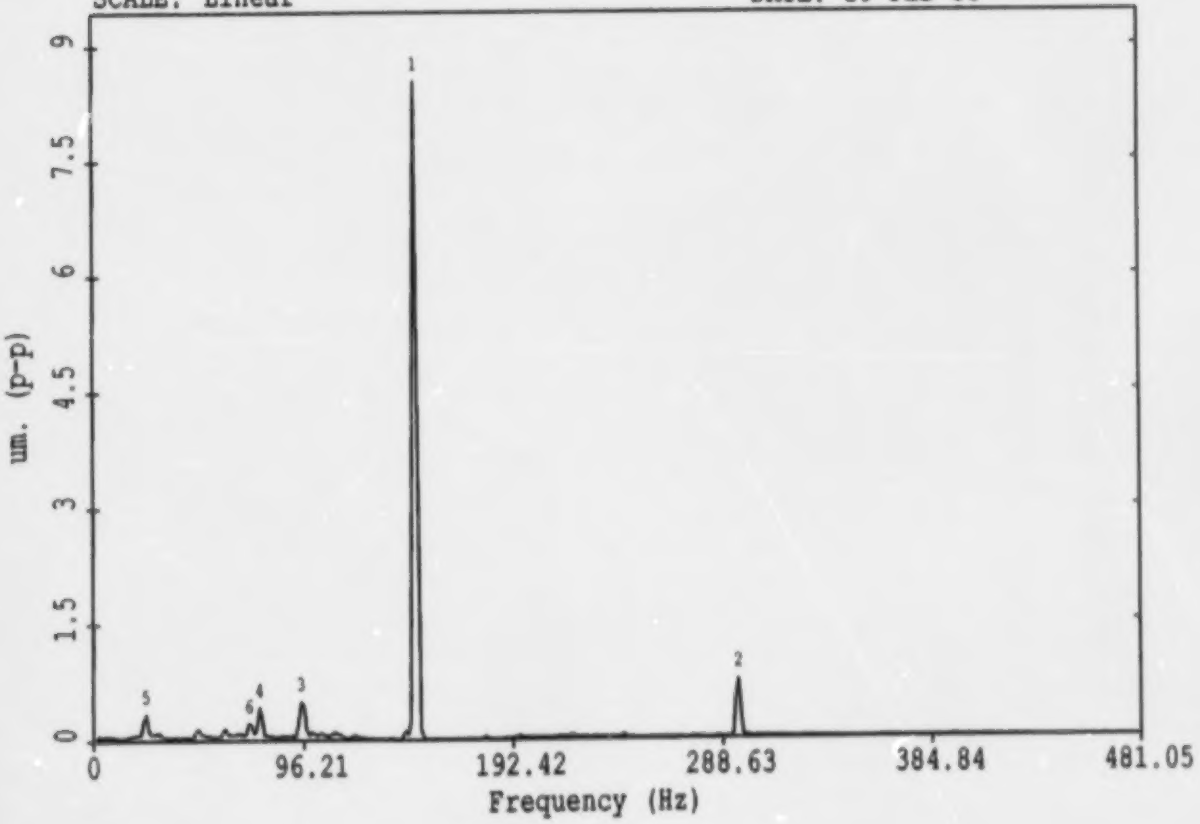


FIGURE F25

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	152.7	10.31
2	97.4	1.94
3	75.8	0.75
4	305.5	0.64
5	60.1	0.41

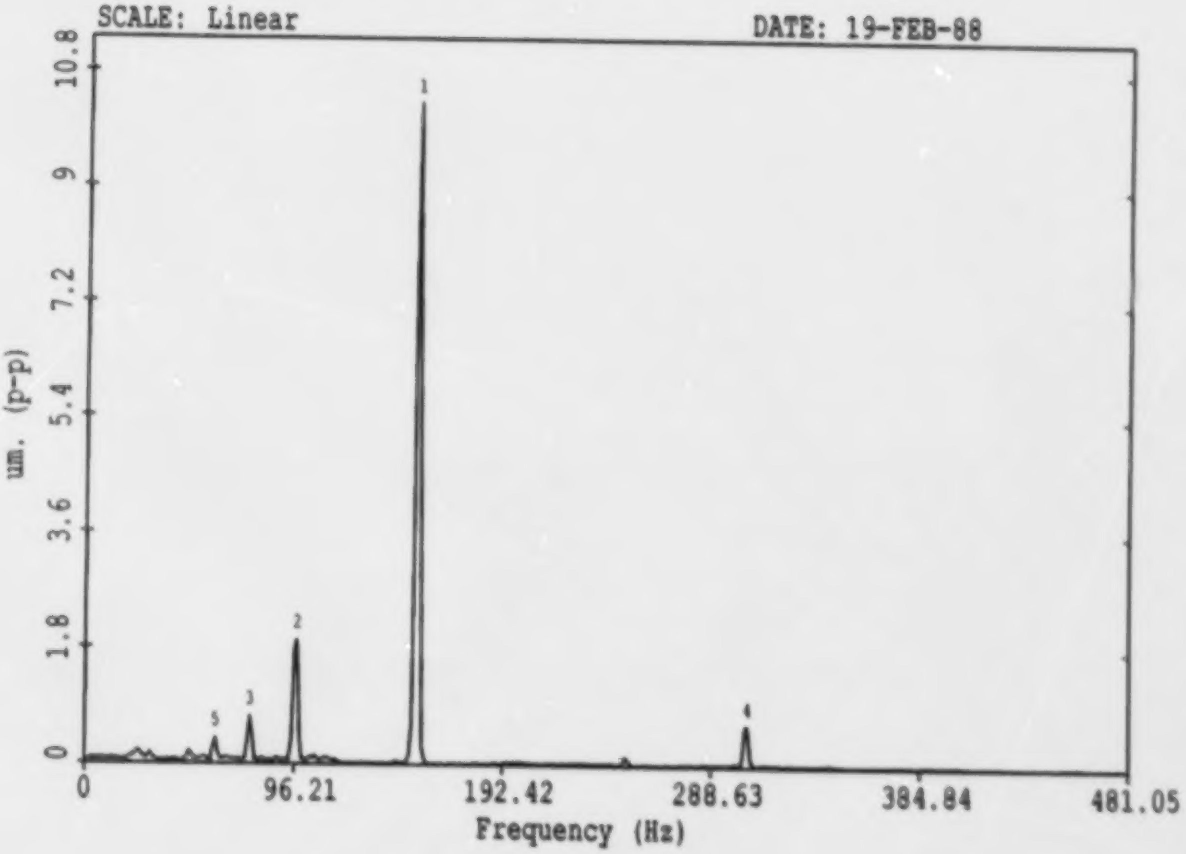


FIGURE F26

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	153.9	9.56
2	309.1	0.64
3	117.9	0.58
4	75.8	0.56
5	60.1	0.42
6	27.7	0.33

SCALE: Linear

DATE: 19-FEB-88

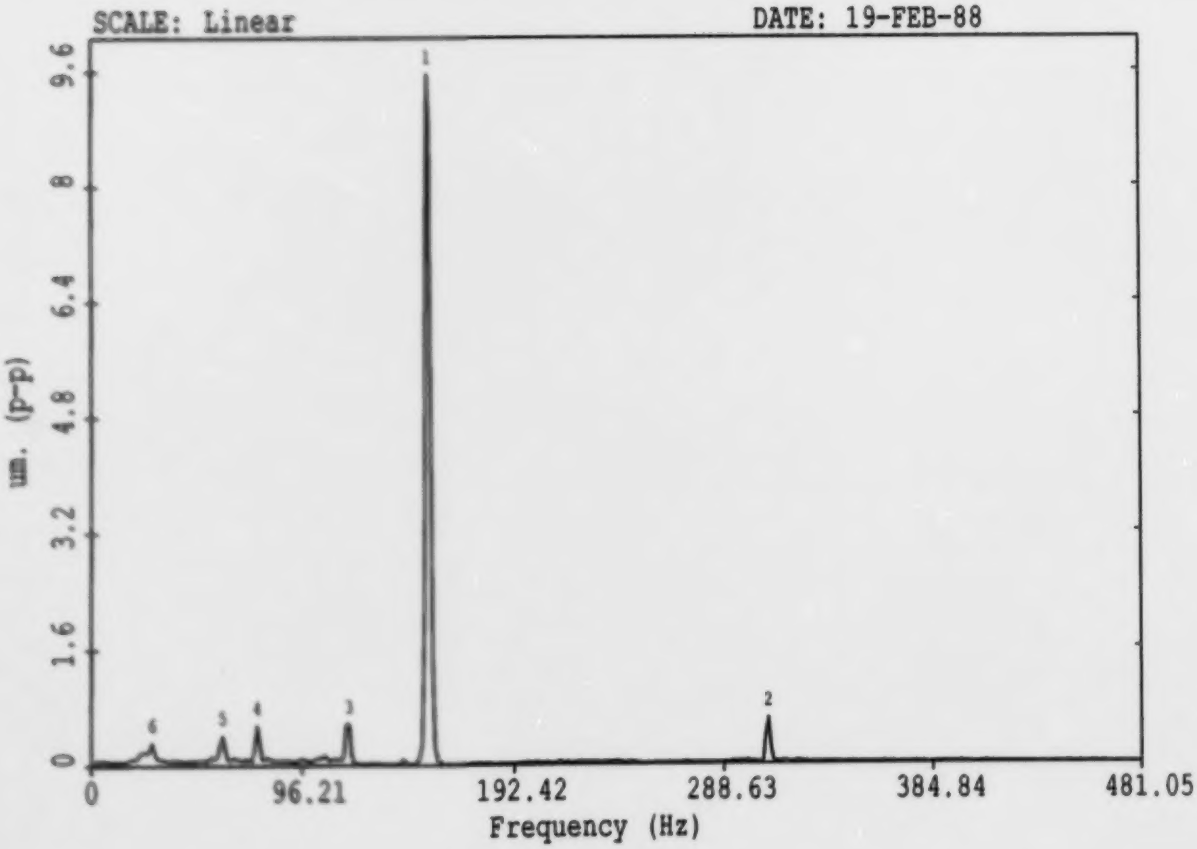


FIGURE F27

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	156.3	9.82
2	311.5	0.68
3	75.8	0.62
4	60.1	0.40
5	27.7	0.38
6	64.9	0.37

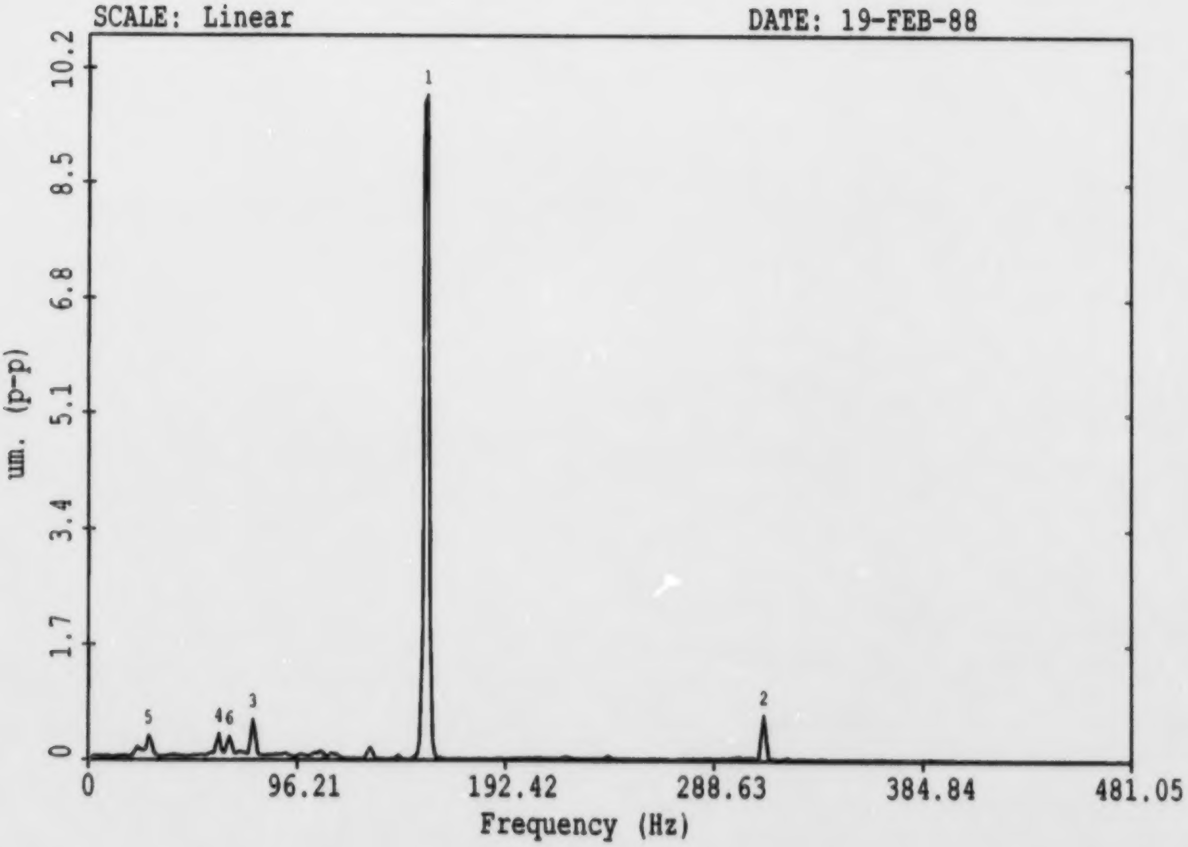


FIGURE F28

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	158.7	11.18
2	60.1	0.87
3	30.1	0.83
4	77.0	0.78
5	316.3	0.72

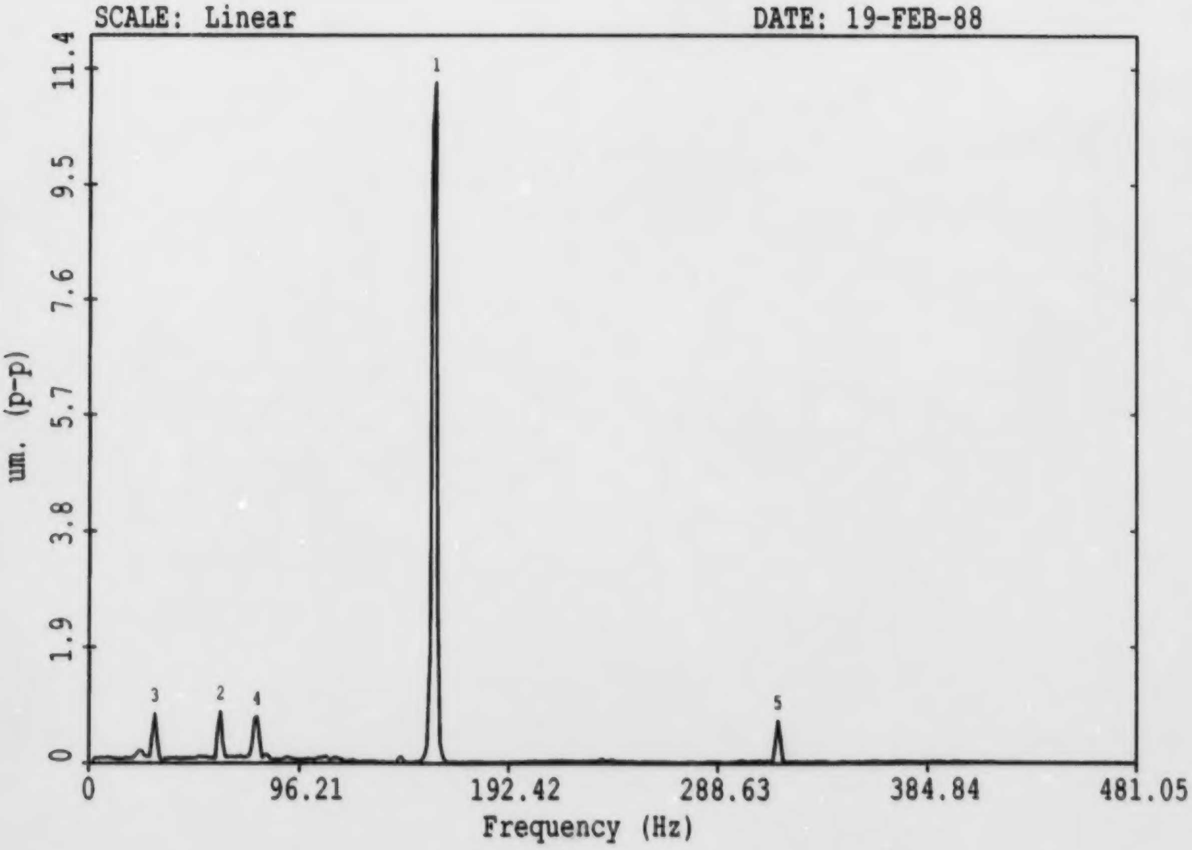


FIGURE F29

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	161.2	13.23
2	90.2	1.68
3	30.1	1.10
4	75.8	0.83
5	321.1	0.65
6	60.1	0.62
7	22.9	0.33

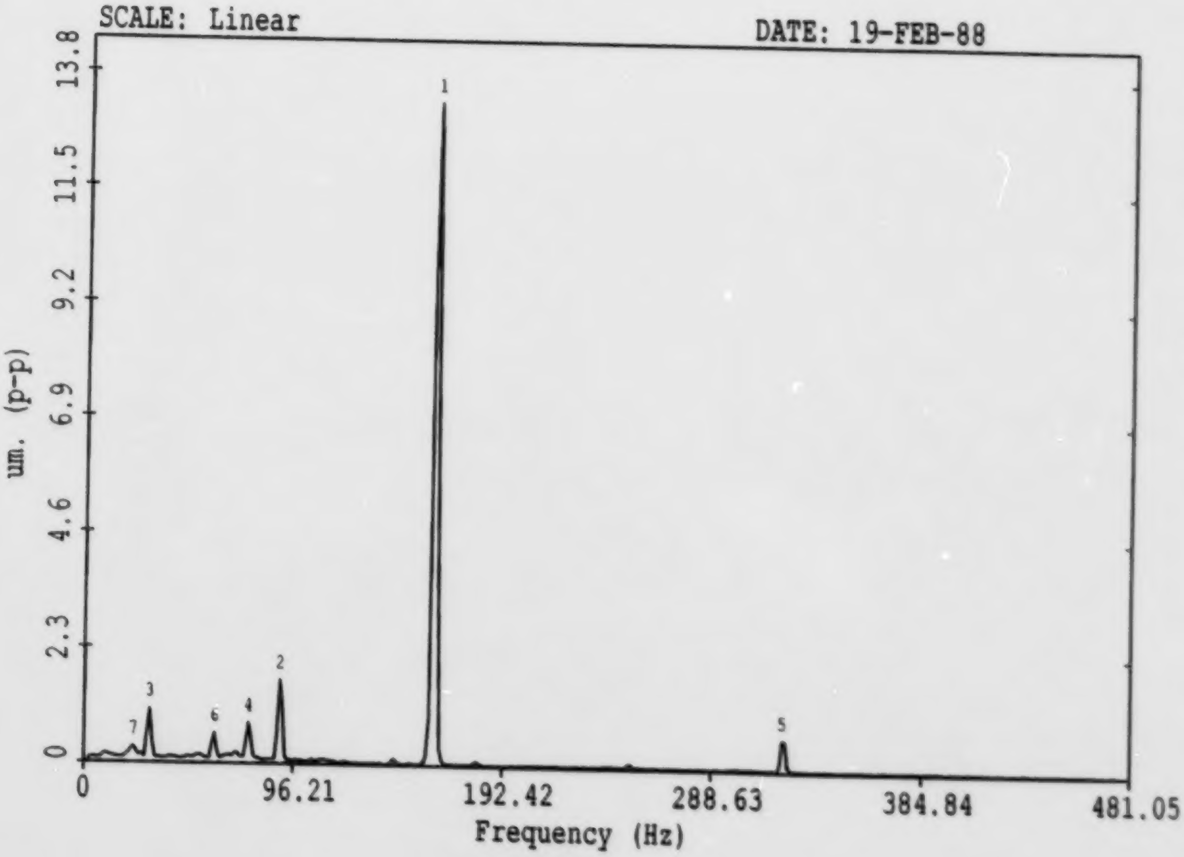


FIGURE F30

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	162.4	13.81
2	98.6	1.75
3	30.1	1.16
4	75.8	0.86
5	324.7	0.60
6	60.1	0.53
7	22.9	0.31

SCALE: Linear

DATE: 19-FEB-88

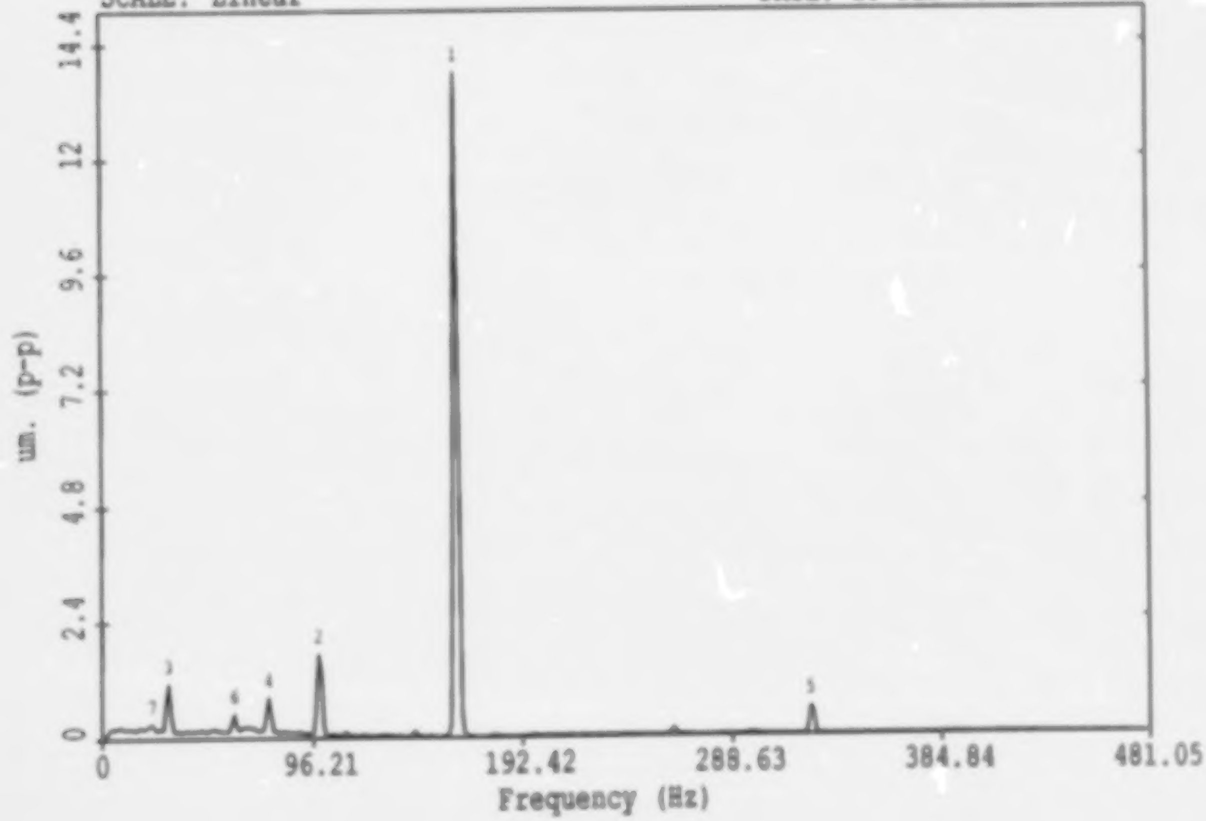


FIGURE F31

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #2 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	167.2	14.18
2	30.1	1.39
3	75.8	0.91
4	123.9	0.88
5	335.5	0.52
6	60.1	0.51
7	14.4	0.38
8	8.4	0.36
9	66.1	0.35
10	68.6	0.34

SCALE: Linear

DATE: 19-FEB-88

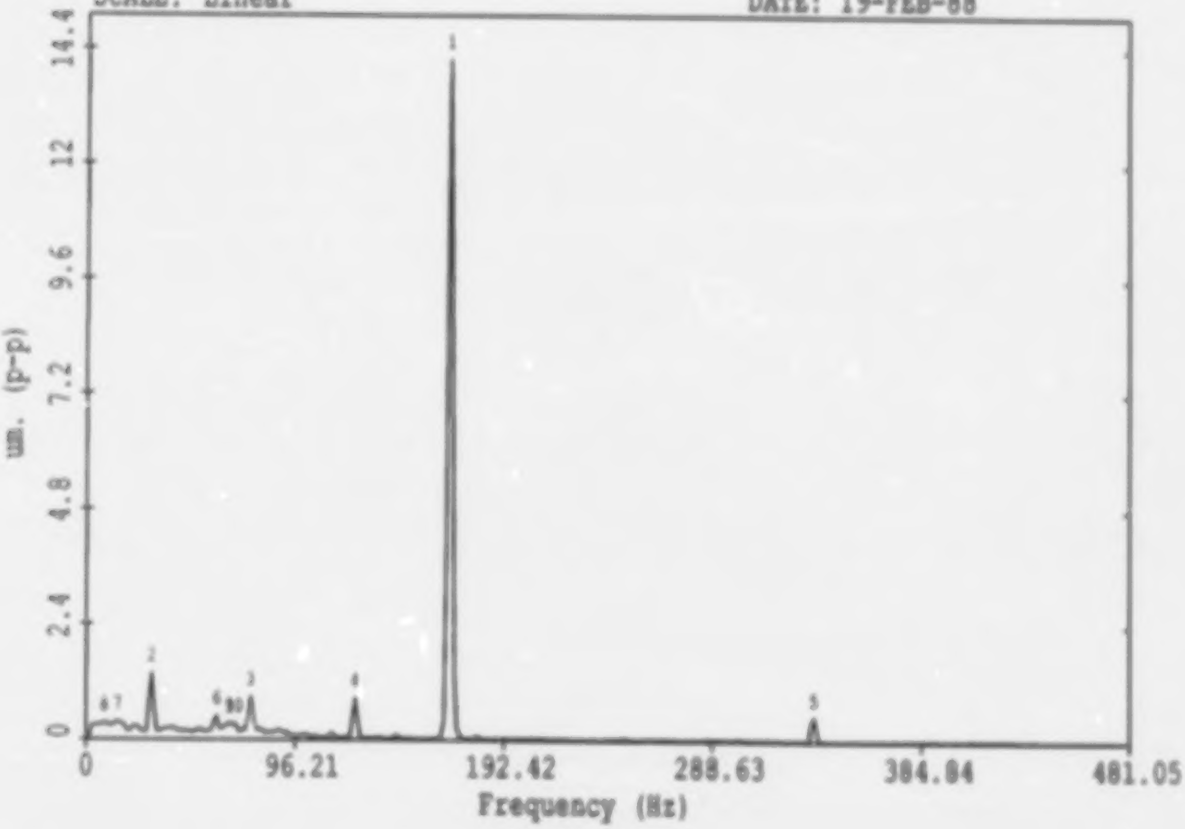


FIGURE F32

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	147.9	4.02
2	8.4	0.54
3	295.8	0.49
4	6.0	0.38
5	14.4	0.33
6	60.1	0.28
7	143.1	0.28
8	30.1	0.27
9	19.2	0.27
10	27.7	0.26

SCALE: Linear

DATE: 19-FEB-88

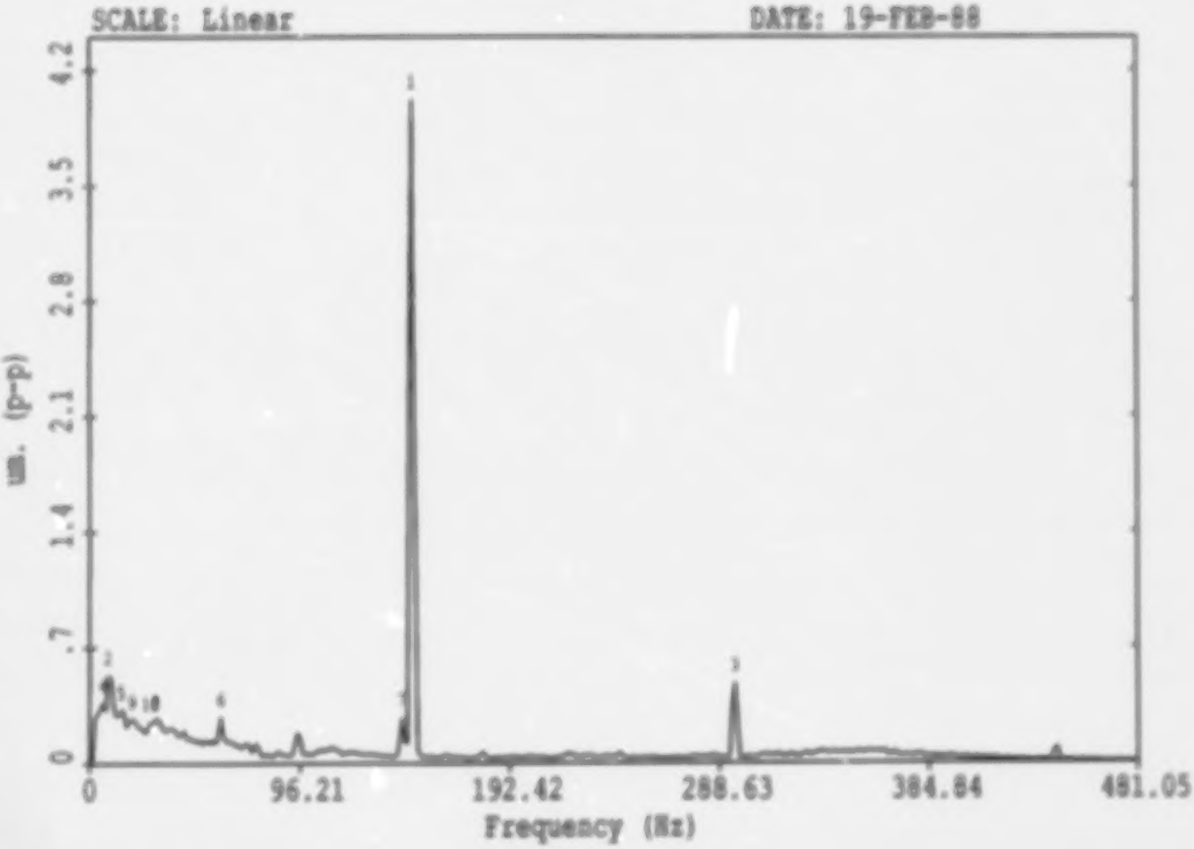


FIGURE F33

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	152.7	2.82
2	54.1	0.78
3	97.4	0.73
4	13.2	0.56
5	6.0	0.54
6	19.2	0.36
7	305.5	0.33
8	24.1	0.32
9	27.7	0.31
10	31.3	0.28

SCALE: Linear

DATE: 19-FEB-88

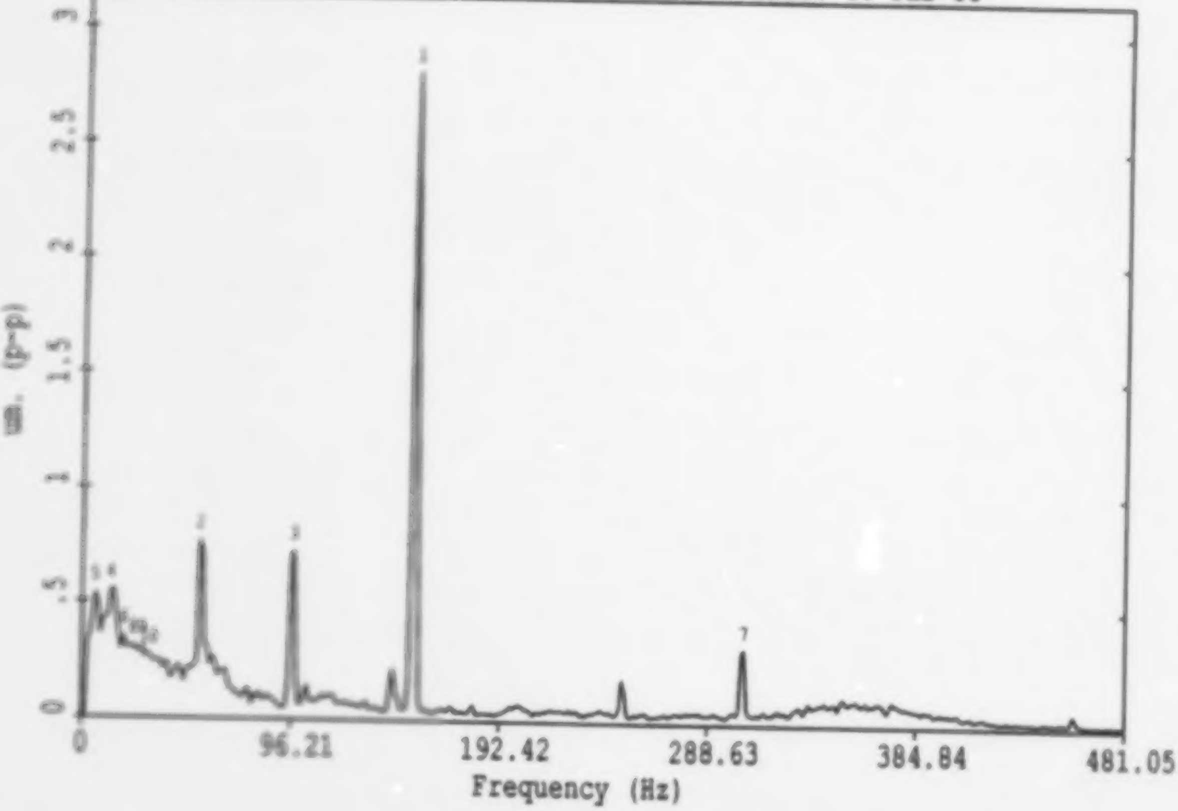


FIGURE F34

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	153.9	1.26
2	7.2	0.69
3	55.3	0.69
4	12.0	0.58
5	18.0	0.48
6	309.1	0.44
7	25.3	0.40
8	30.1	0.35
9	33.7	0.31
10	38.5	0.31

SCALE: Linear DATE: 19-FEB-88

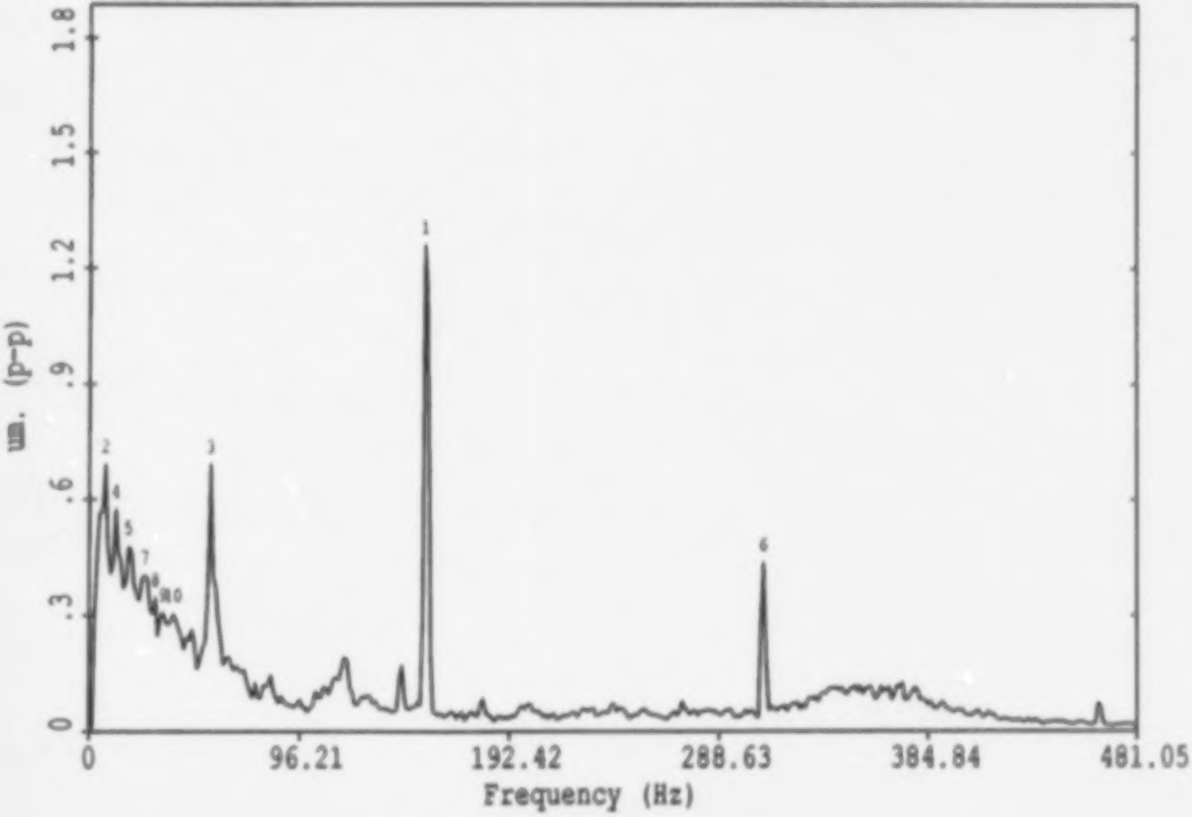


FIGURE F35

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	156.3	0.98
2	56.5	0.84
3	6.0	0.82
4	15.6	0.45
5	20.4	0.43
6	27.7	0.42
7	311.5	0.39
8	22.9	0.39
9	31.3	0.34
10	33.7	0.33

SCALE: Linear

DATE: 19-FEB-88

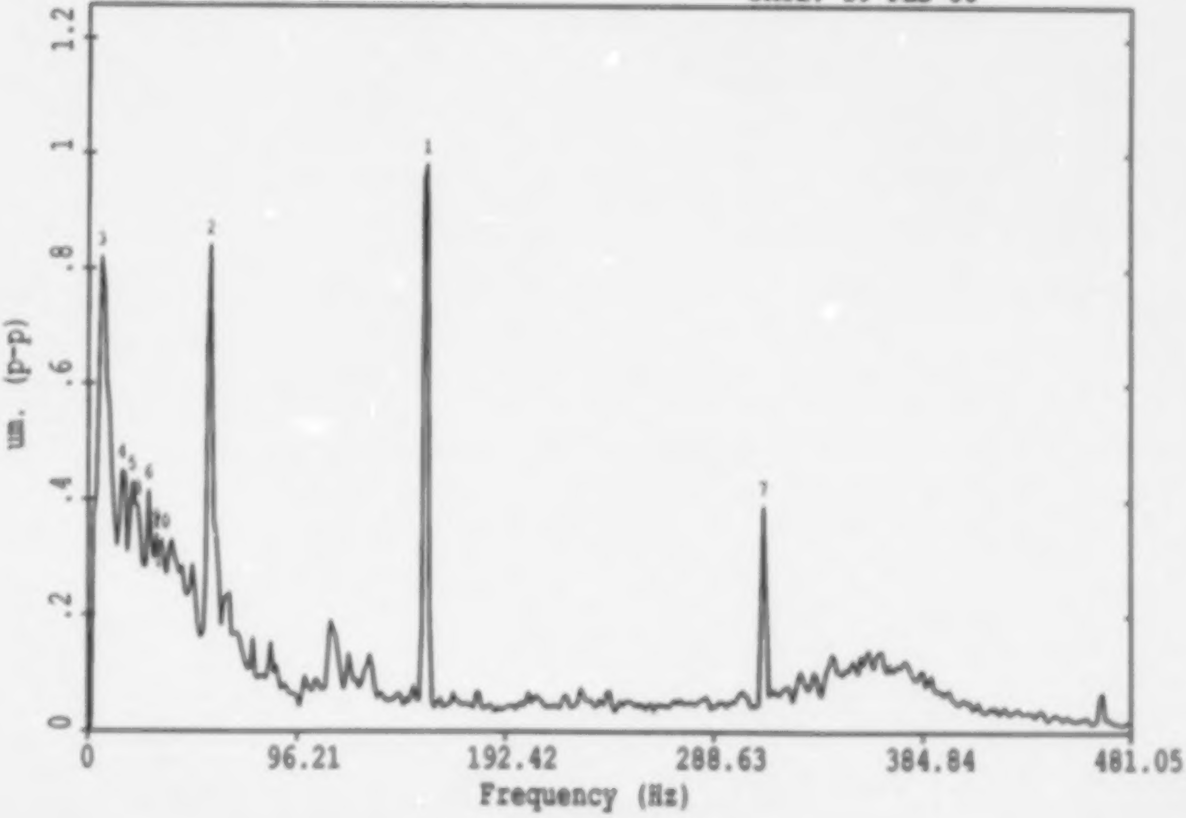


FIGURE F36

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	158.7	1.73
2	60.1	0.99
3	30.1	0.92
4	7.2	0.90
5	13.2	0.47
6	316.3	0.45
7	26.5	0.40
8	45.7	0.40
9	22.9	0.39
10	34.9	0.37

SCALE: Linear DATE: 19-FEB-88

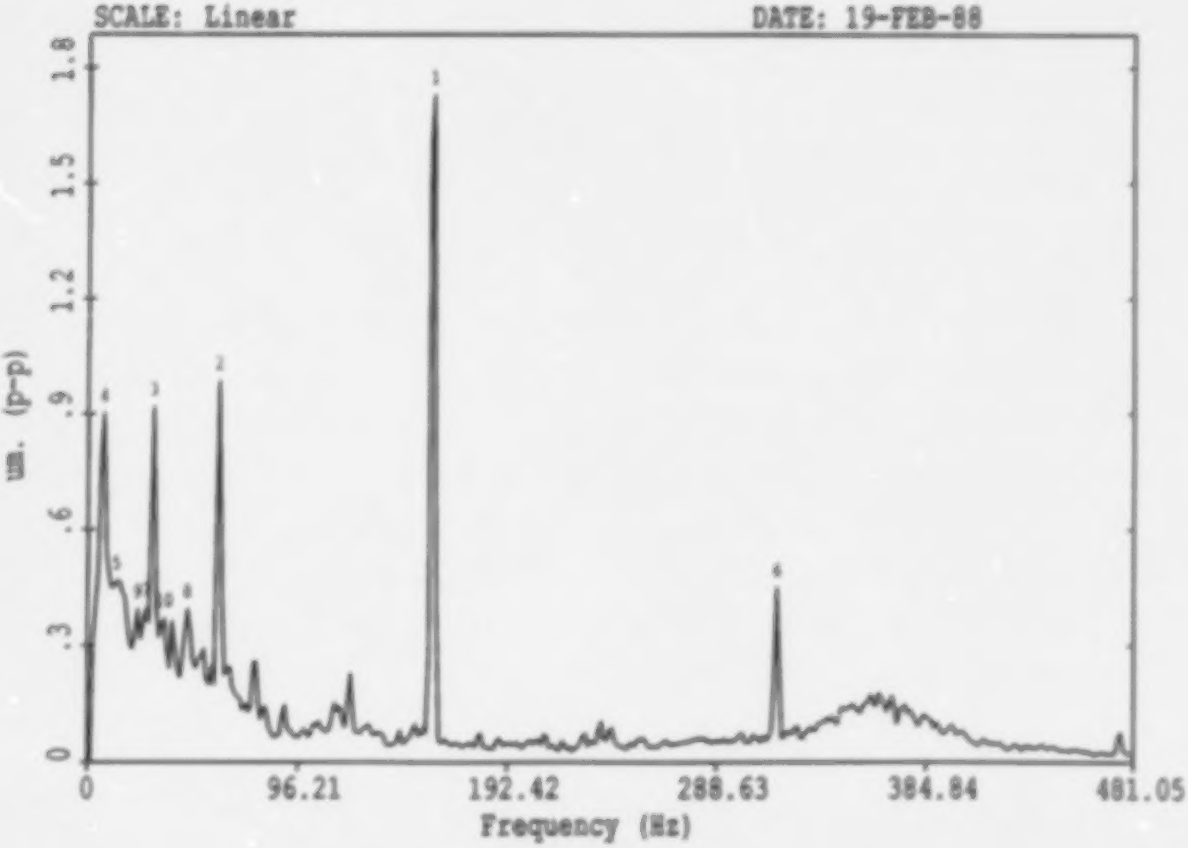


FIGURE F37

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	161.2	2.71
2	6.0	1.06
3	30.1	1.05
4	60.1	0.90
5	90.2	0.55
6	12.0	0.47
7	321.1	0.45
8	21.6	0.44
9	75.8	0.43
10	15.6	0.42

SCALE: Linear

DATE: 19-FEB-88

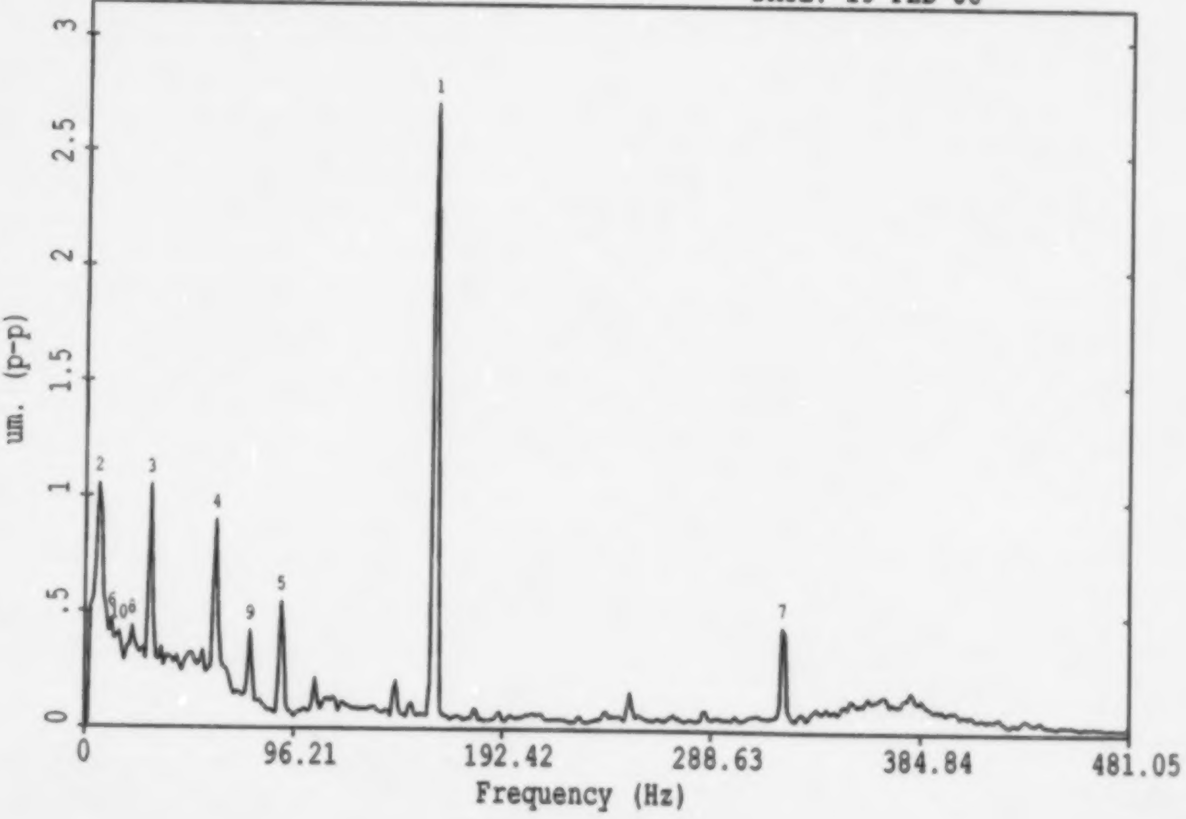


FIGURE F38

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	162.4	3.52
2	30.1	1.22
3	4.8	0.87
4	98.6	0.78
5	60.1	0.69
6	75.8	0.65
7	15.6	0.52
8	324.7	0.50
9	19.2	0.48
10	24.1	0.41

SCALE: Linear

DATE: 19-FEB-88

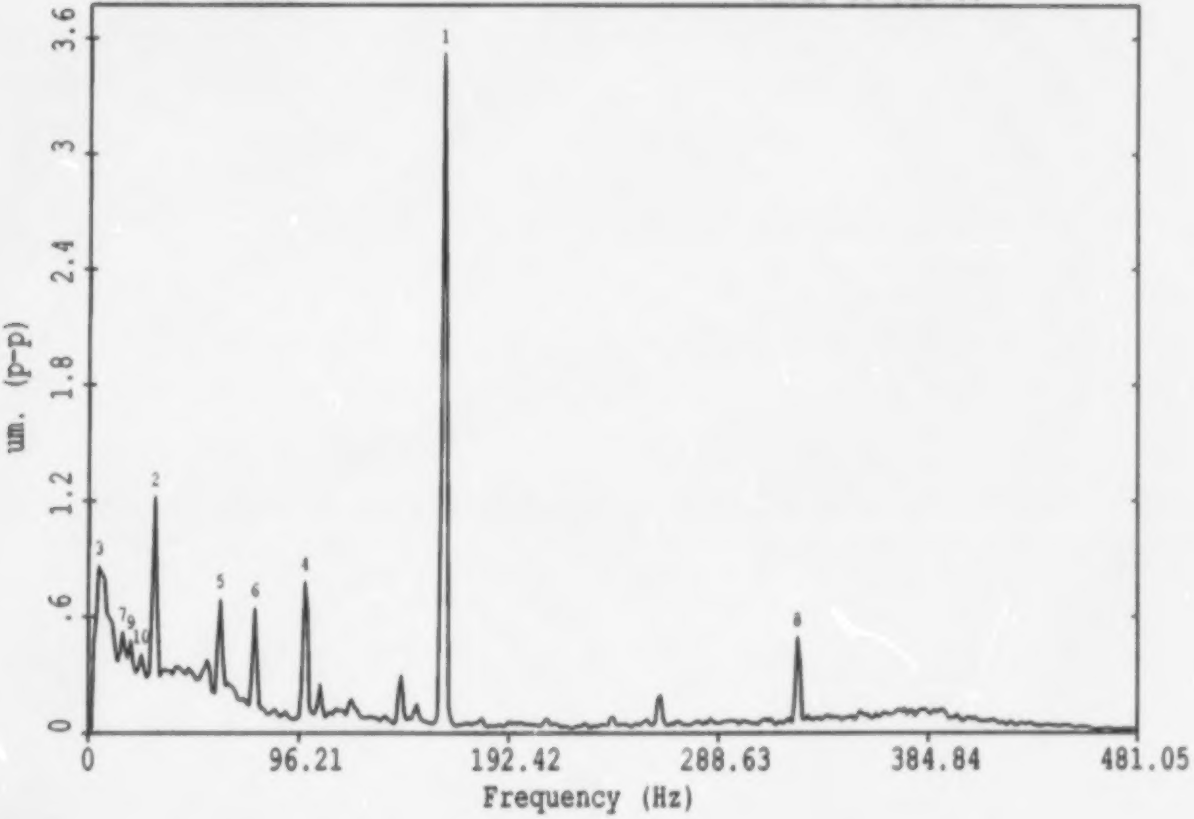


FIGURE F39

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT VERT.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	167.2	2.19
2	30.1	1.39
3	60.1	1.17
4	75.8	1.15
5	7.2	0.97
6	13.2	0.52
7	38.5	0.51
8	335.5	0.50
9	143.1	0.41
10	26.5	0.39

SCALE: Linear

DATE: 19-FEB-88

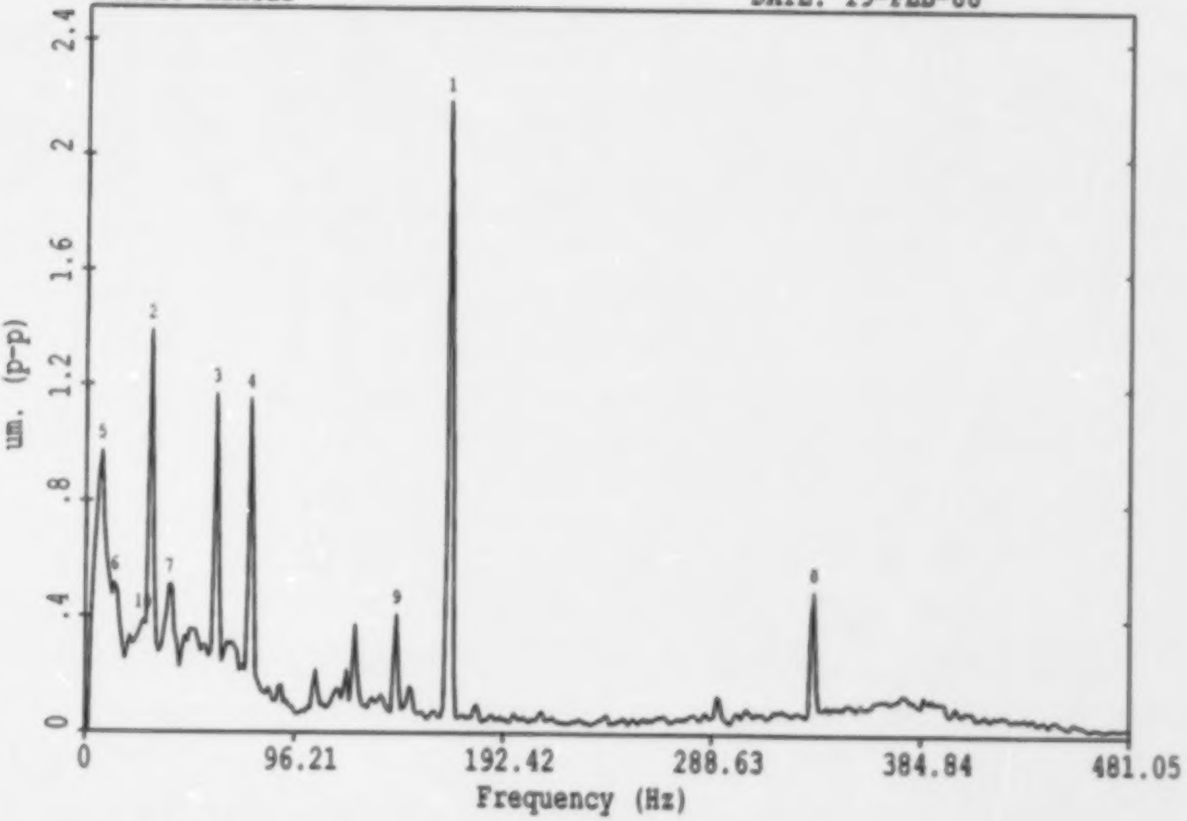


FIGURE F40

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	147.9	1.73
2	60.1	0.33
3	8.4	0.27
4	24.1	0.24
5	295.8	0.22
6	6.0	0.18
7	95.0	0.18
8	30.1	0.17
9	75.8	0.17
10	15.6	0.16

SCALE: Linear

DATE: 19-FEB-88

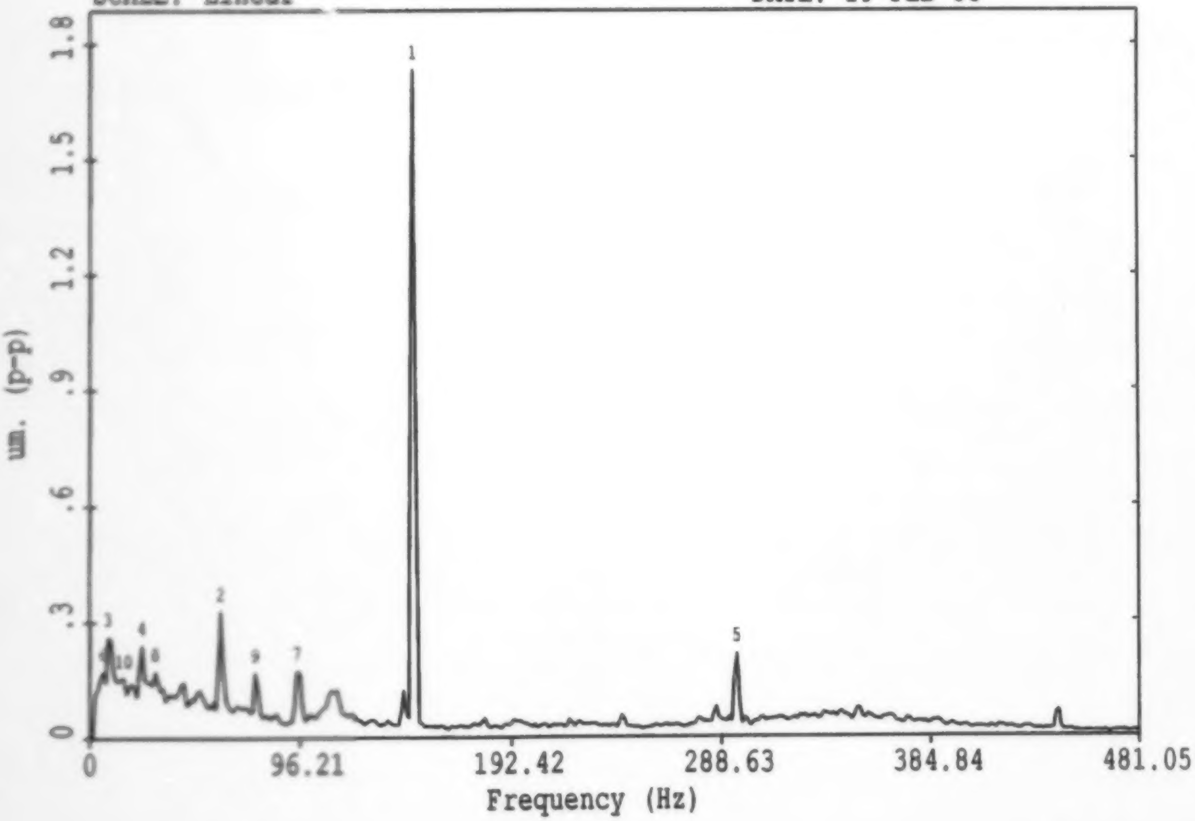


FIGURE F41

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	152.7	2.69
2	97.4	0.64
3	54.1	0.41
4	60.1	0.40
5	75.8	0.27
6	305.5	0.24
7	115.5	0.22
8	49.3	0.19
9	24.1	0.19
10	30.1	0.18

SCALE: Linear

DATE: 19-FEB-88

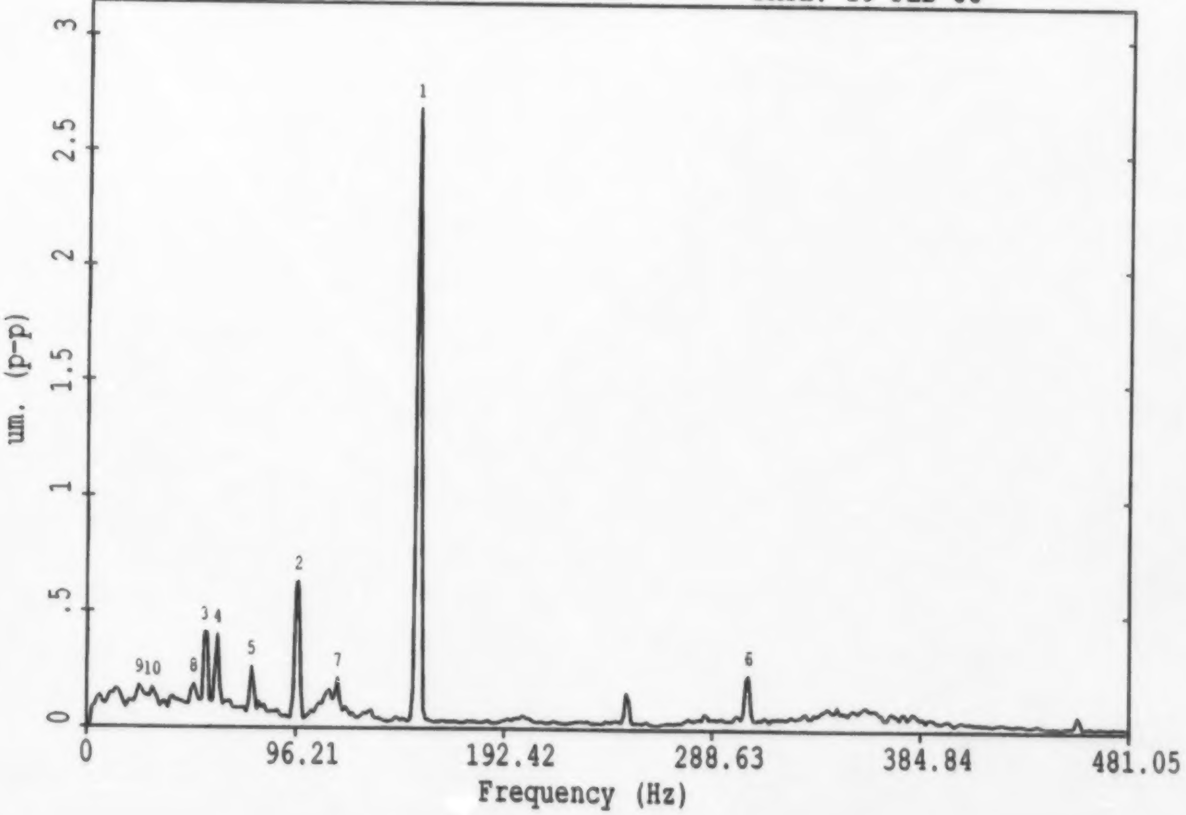


FIGURE F42

DARLINGTON NG A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 1.5 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	153.9	2.37
2	60.1	0.47
3	117.9	0.27
4	309.1	0.27
5	55.3	0.25
6	75.8	0.23
7	27.7	0.23
8	40.9	0.20
9	111.8	0.18
10	51.7	0.16

SCALE: Linear DATE: 19-FEB-88

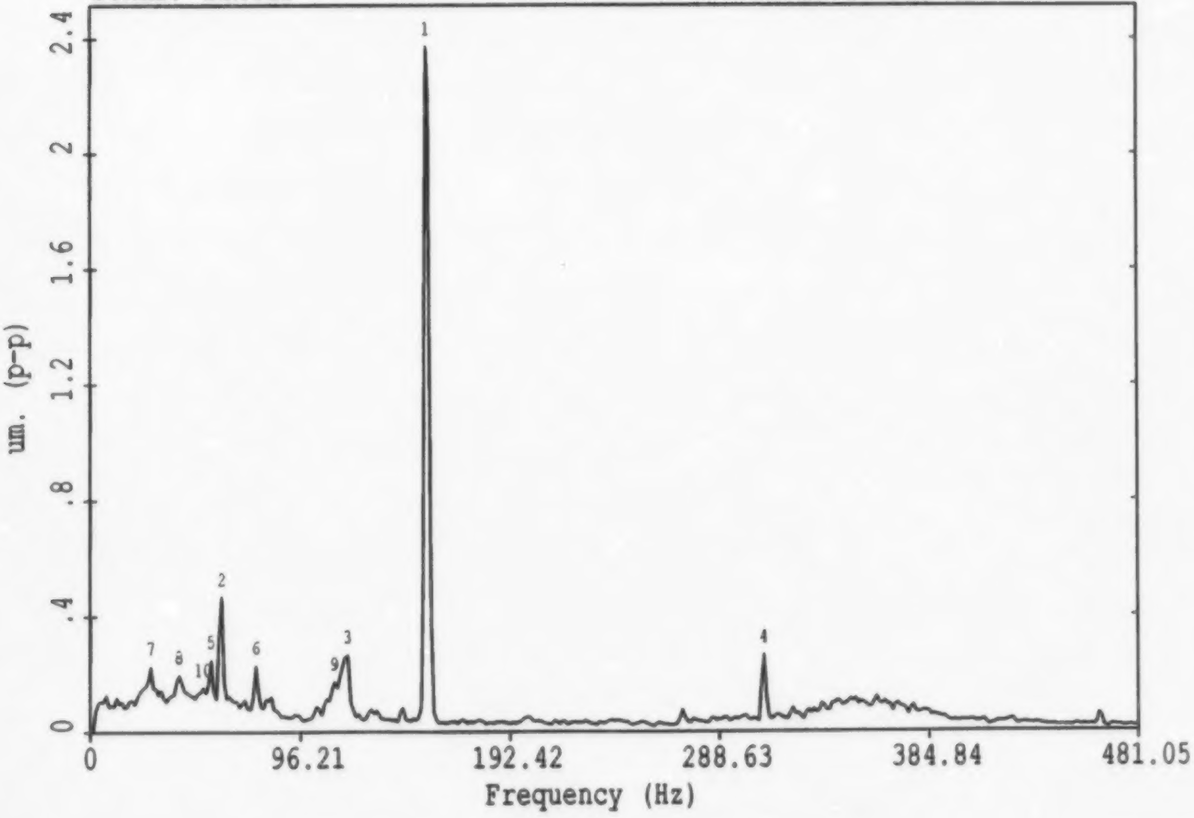


FIGURE F43

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 2.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	156.3	2.42
2	60.1	0.53
3	56.5	0.32
4	311.5	0.28
5	27.7	0.27
6	75.8	0.27
7	42.1	0.22
8	114.3	0.21
9	111.8	0.20
10	22.9	0.17

SCALE: Linear

DATE: 19-FEB-88

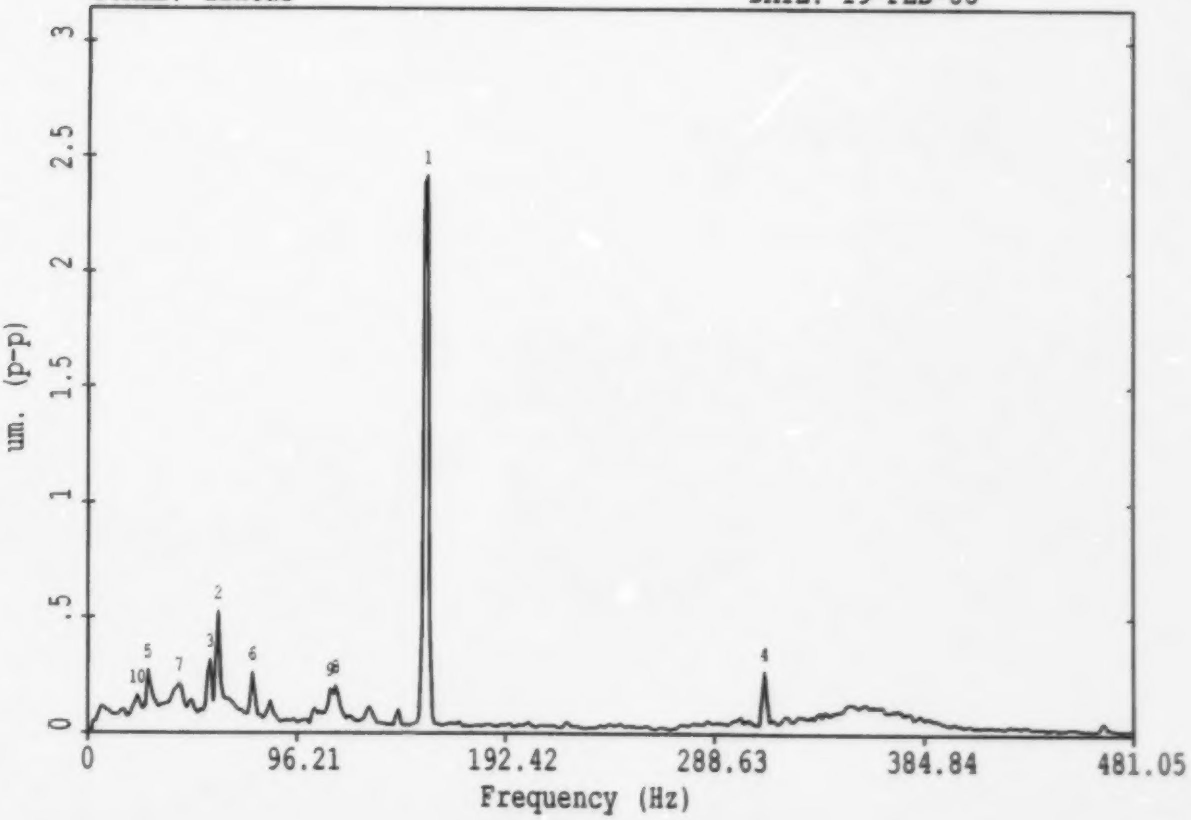


FIGURE F44

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 3 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	158.7	2.30
2	60.1	1.31
3	30.1	0.97
4	75.8	0.47
5	316.3	0.29
6	143.1	0.21
7	359.6	0.20
8	40.9	0.20
9	34.9	0.18
10	364.4	0.17

SCALE: Linear

DATE: 19-FEB-88

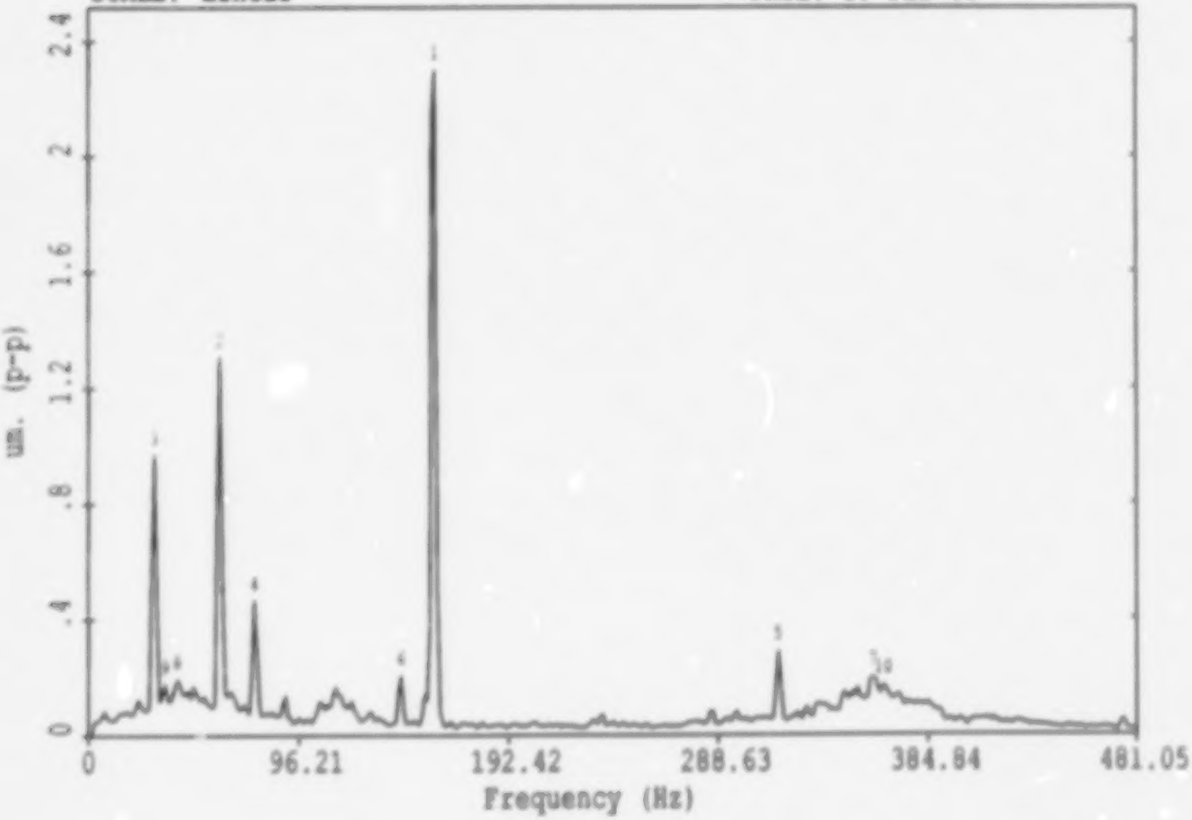


FIGURE F45

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 4.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	161.2	2.39
2	30.1	1.13
3	90.2	0.75
4	75.8	0.64
5	321.1	0.33
6	143.1	0.25
7	49.3	0.23
8	60.1	0.22
9	120.3	0.20
10	46.9	0.19

SCALE: Linear

DATE: 19-FEB-88

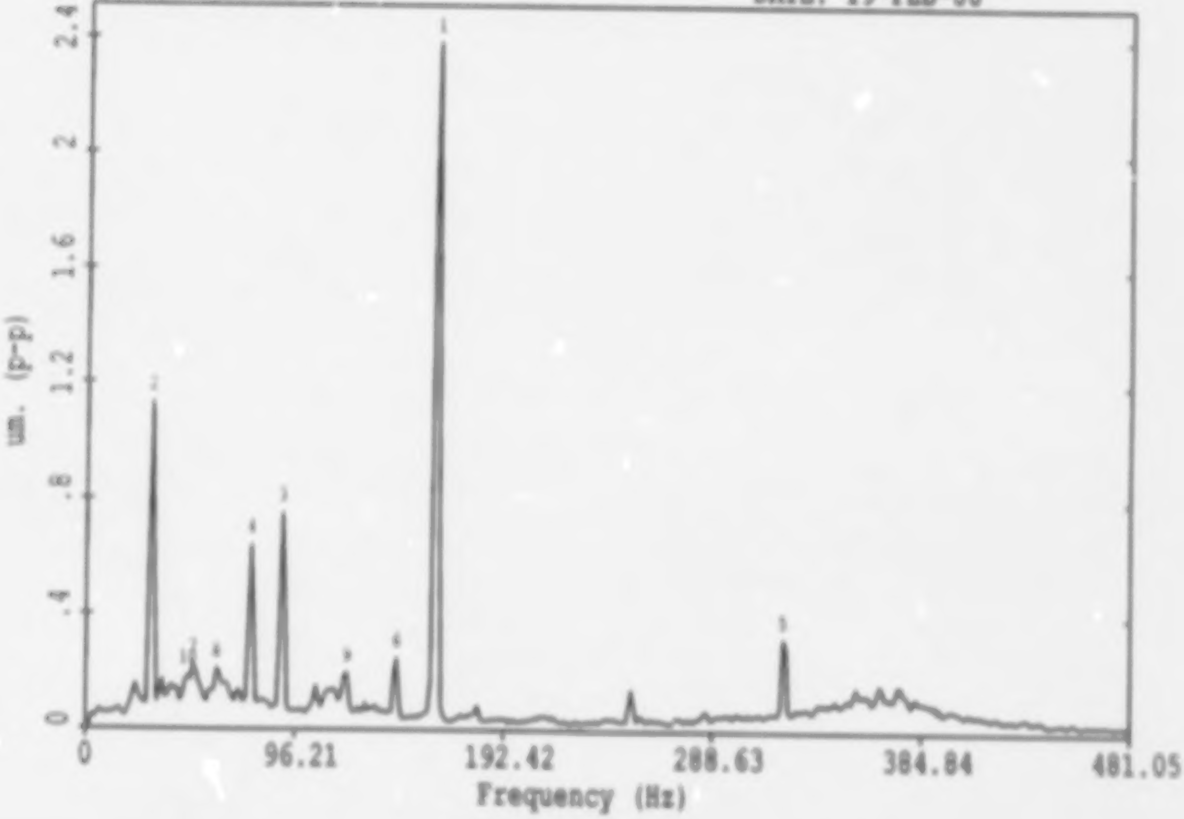


FIGURE F46

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 5.0 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	162.4	2.21
2	30.1	1.08
3	98.6	0.80
4	75.8	0.77
5	324.7	0.41
6	60.1	0.38
7	143.1	0.25
8	40.9	0.23
9	48.1	0.19
10	63.7	0.19

SCALE: Linear

DATE: 19-FEB-88

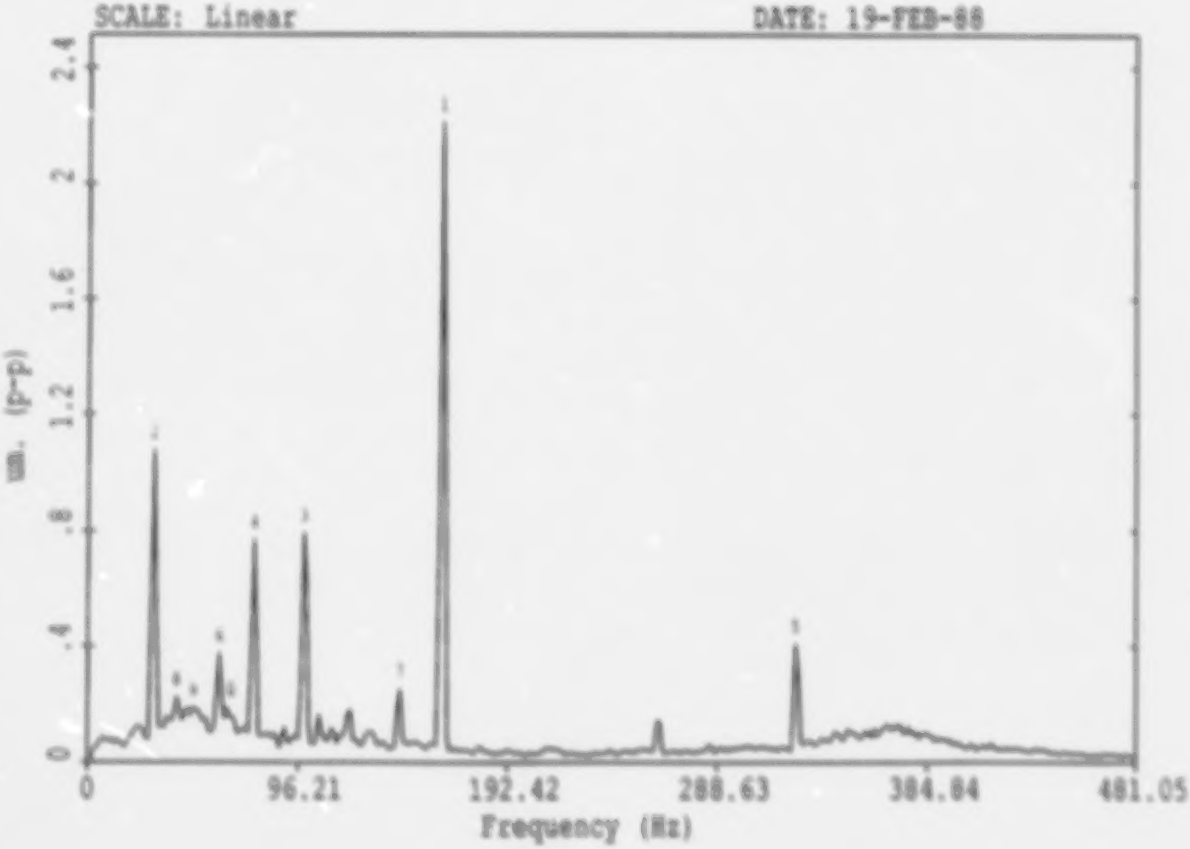


FIGURE F47

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2

SIGNAL : GP BEARING #3 - SHAFT DISPLACEMENT HOR.
PROCESS CONDITION : LOAD 6.8 MW

PEAK NO.	FREQUENCY	AMPLITUDE
1	167.2	1.94
2	30.1	1.13
3	75.8	1.03
4	60.1	0.74
5	335.5	0.43
6	39.7	0.41
7	123.9	0.31
8	120.3	0.28
9	50.5	0.26
10	48.1	0.25

SCALE: Linear DATE: 19-FEB-88

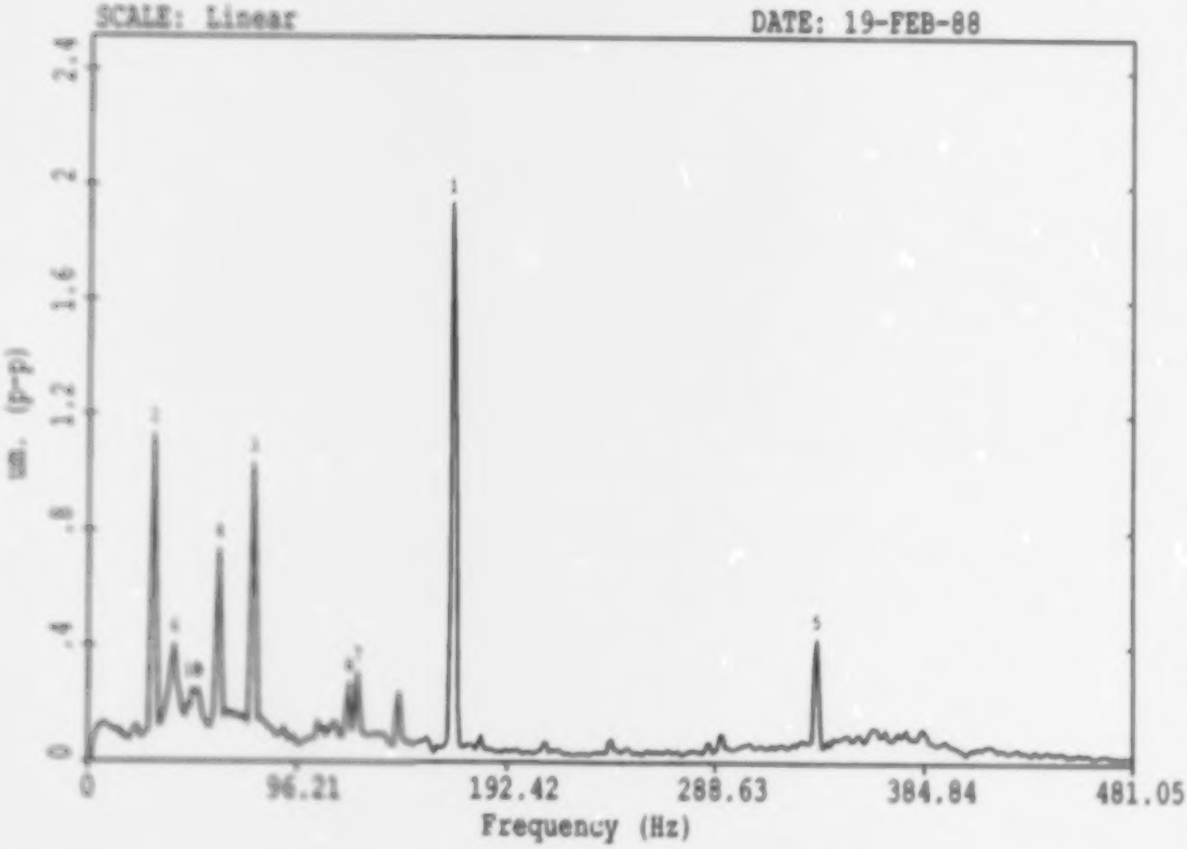


FIGURE F48

APPENDIX G

BODE PLOTS OF VIBRATION DURING COLD START RUNUP

TABLE G1
DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
FIGURE NUMBERS FOR BODE PLOTS OF VIBRATION DURING COLD START RUNUP

Measurement		Figure No of Bode Plot
AC Generator Outboard Bearing Casing Velocity	- Vertical Direction	G1
	- Horizontal Direction	G2
AC Generator Inboard Bearing Casing Velocity	- Vertical Direction	G3
	- Horizontal Direction	G4
Power Turbine Bearing No 5 Casing Velocity	- Vertical Direction	G5
	- Horizontal Direction	G6
	- Axial Direction	G7
AC Generator Outboard Bearing Shaft Displacement	- Vertical Direction	G8
	- Horizontal Direction	G9
AC Generator Inboard Bearing Shaft Displacement	- Vertical Direction	G10
	- Horizontal Direction	G11
Power Turbine Bearing No 4 Shaft Displacement	- Vertical Direction	G12
	- Horizontal Direction	G13
Power Turbine Bearing No 5 Shaft Displacement	- Vertical Direction	G14
	- Horizontal Direction	G15
Gas Producer Bearing No 1 Shaft Displacement	- Vertical Direction	G16
	- Horizontal Direction	G17
Gas Producer Bearing No 2 Shaft Displacement	- Vertical Direction	G18
	- Horizontal Direction	G19
Gas Producer Bearing No 3 Shaft Displacement	- Vertical Direction	G20
	- Horizontal Direction	G21

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR COLD RUNUP OB BRG CASING VELOCITY VERT.

BODE PLOT Order : 1.00
Date : 19-FEB-88

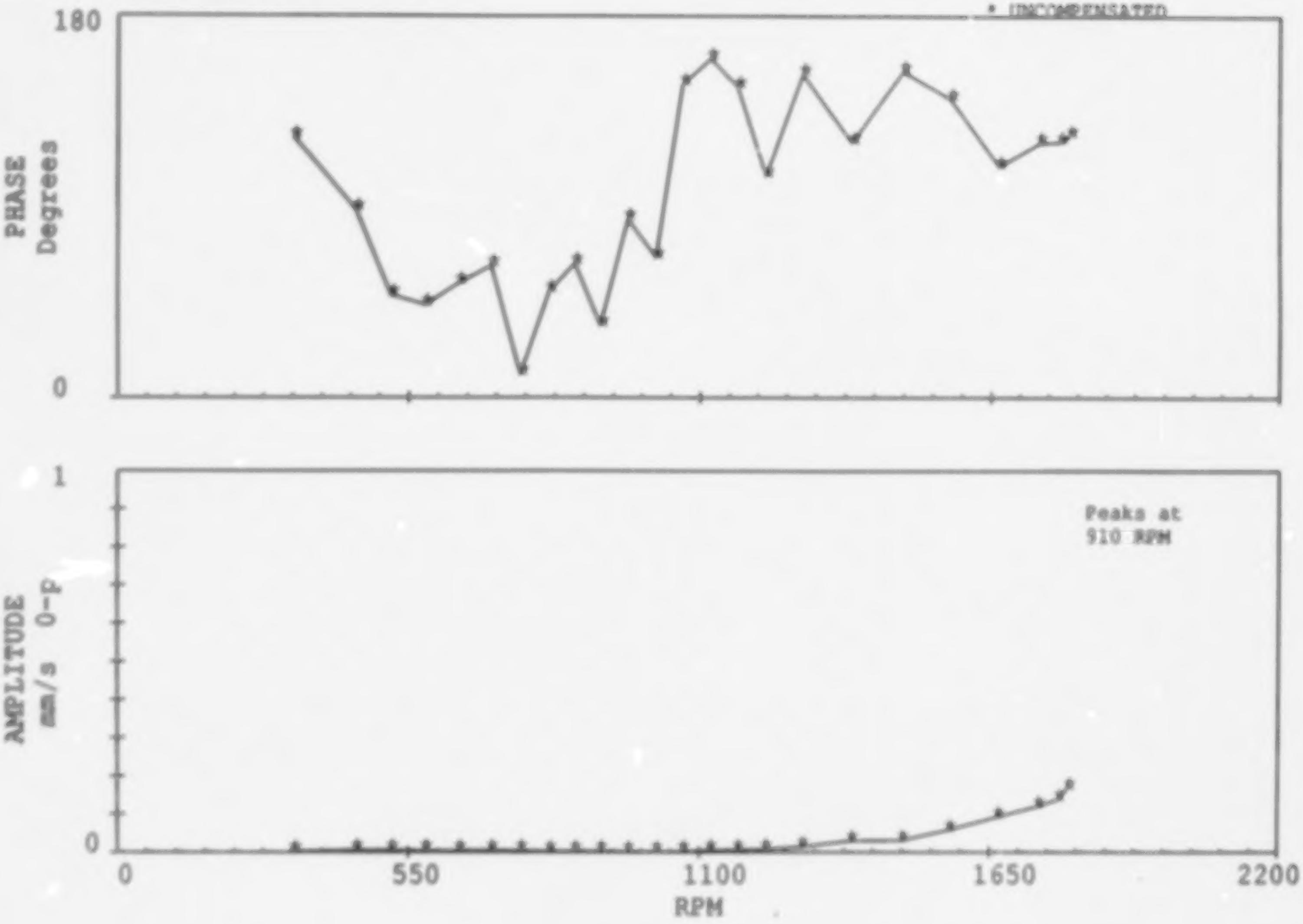


FIGURE G1

90-310

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR COLD RUNUP OB BRG CASING VELOCITY HOR.

BODE PLOT Order : 1.00
Date : 19-FEB-88

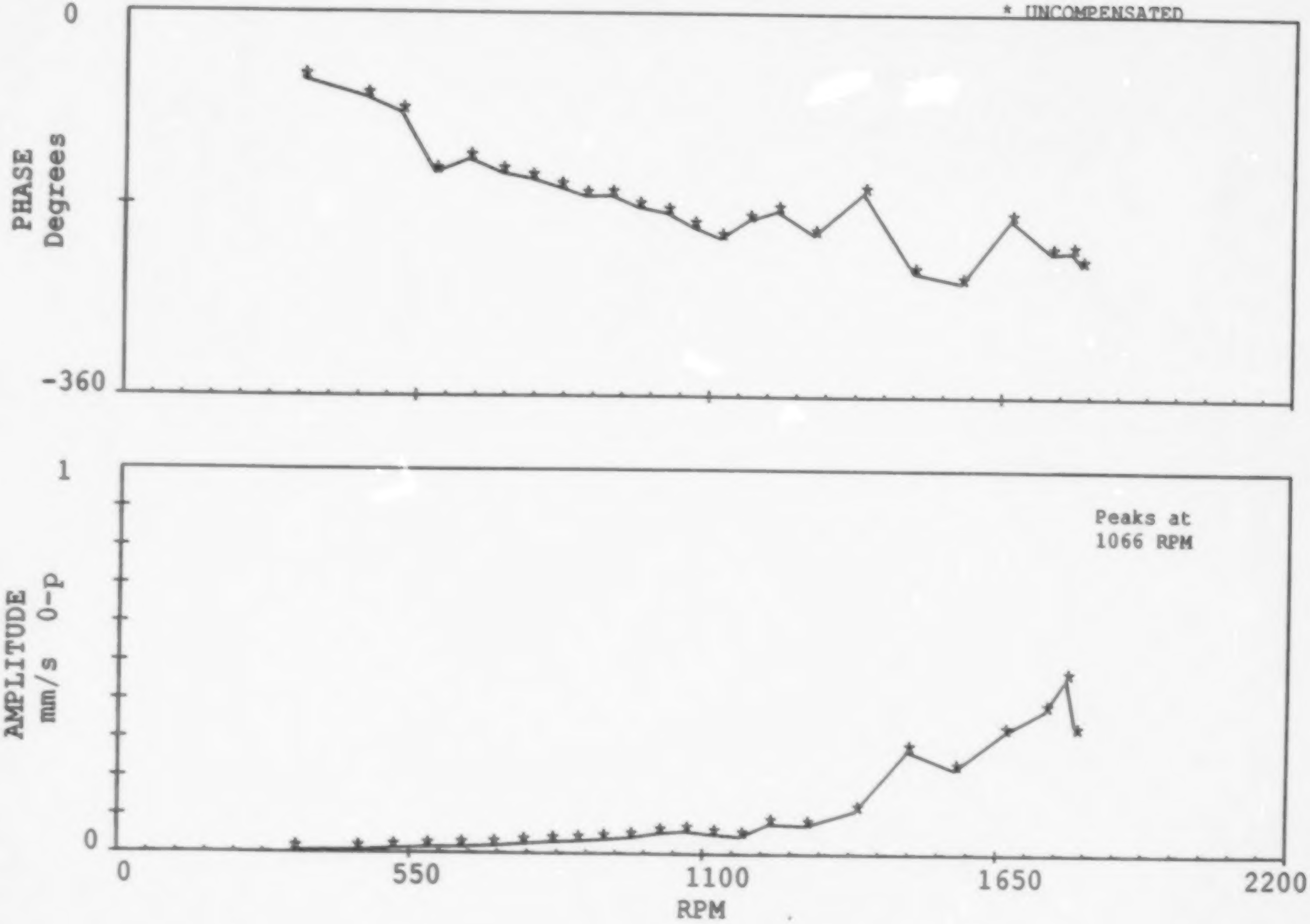


FIGURE G2

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR COLD RUNUP IB BRG CASING VELOCITY VERT.

BODE PLOT Order : 1.00
Date : 19-FEB-88

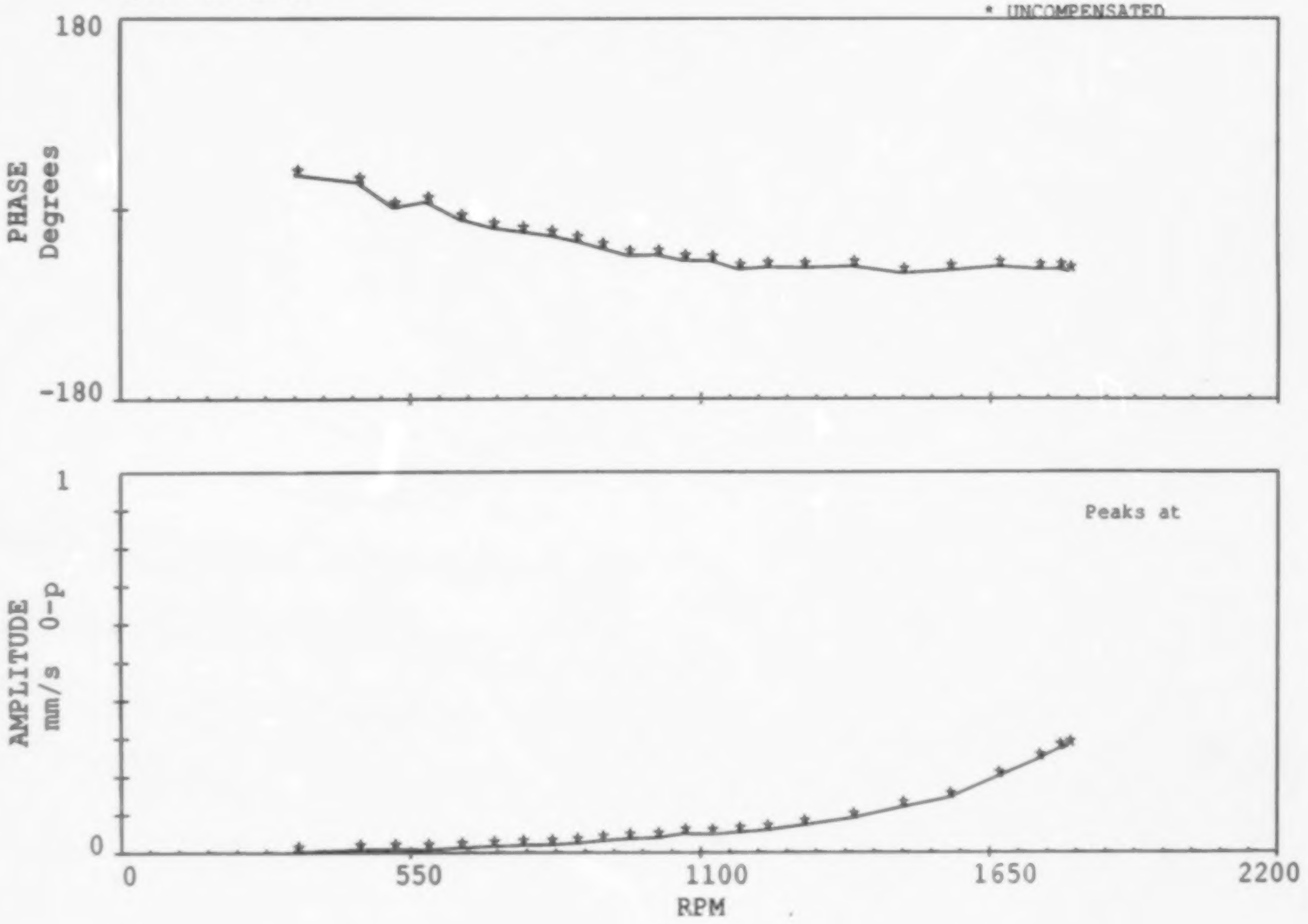


FIGURE G3

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR COLD RUNUP IB BRG CASING VELOCITY HOR.

BODE PLOT Order : 1.00
Date : 19-FEB-88

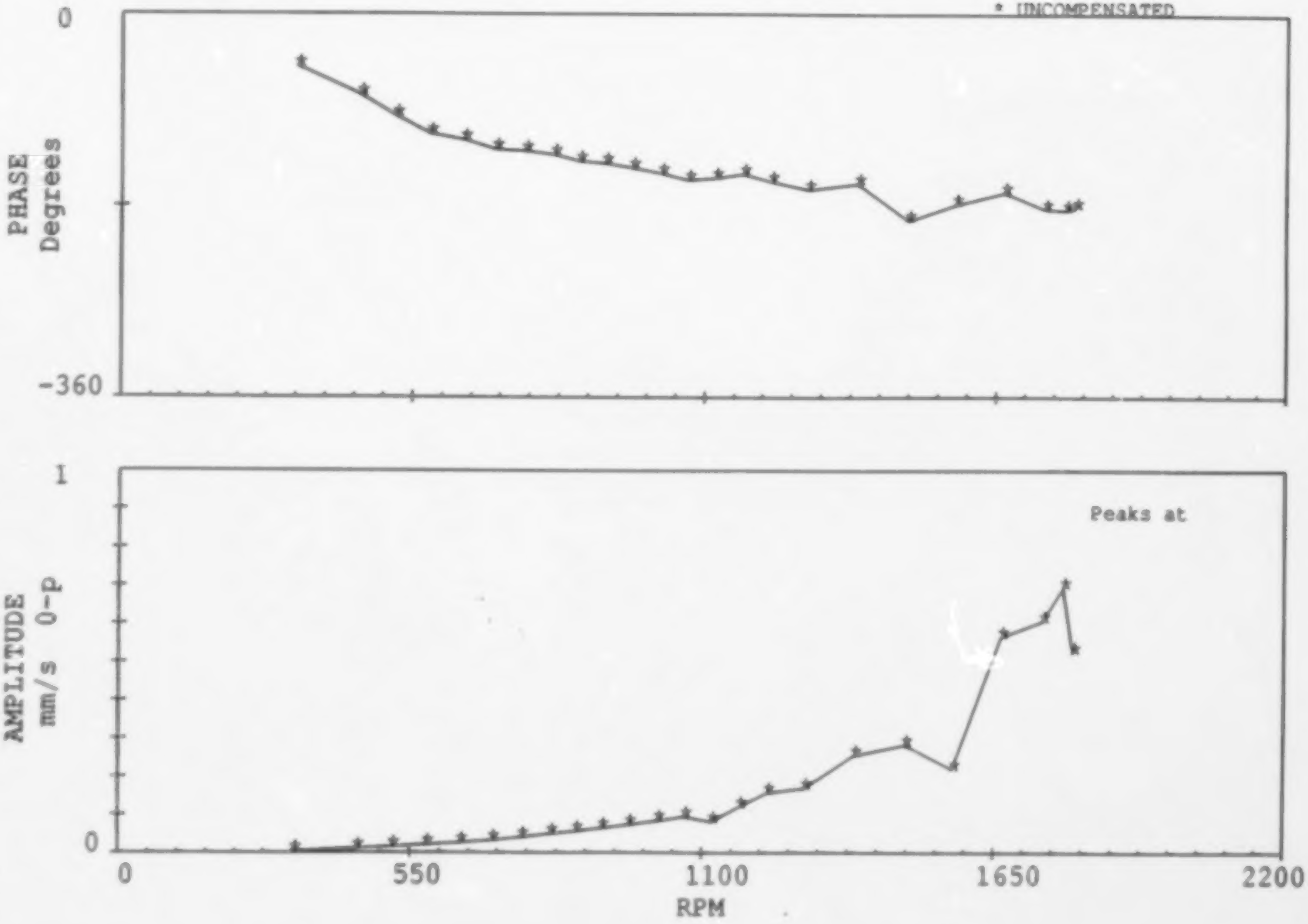


FIGURE G4

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE COLD RUNUP BRG #5 CASING VELOCITY VERT.

BODE PLOT Order : 1.00
Date : 19-FEB-88

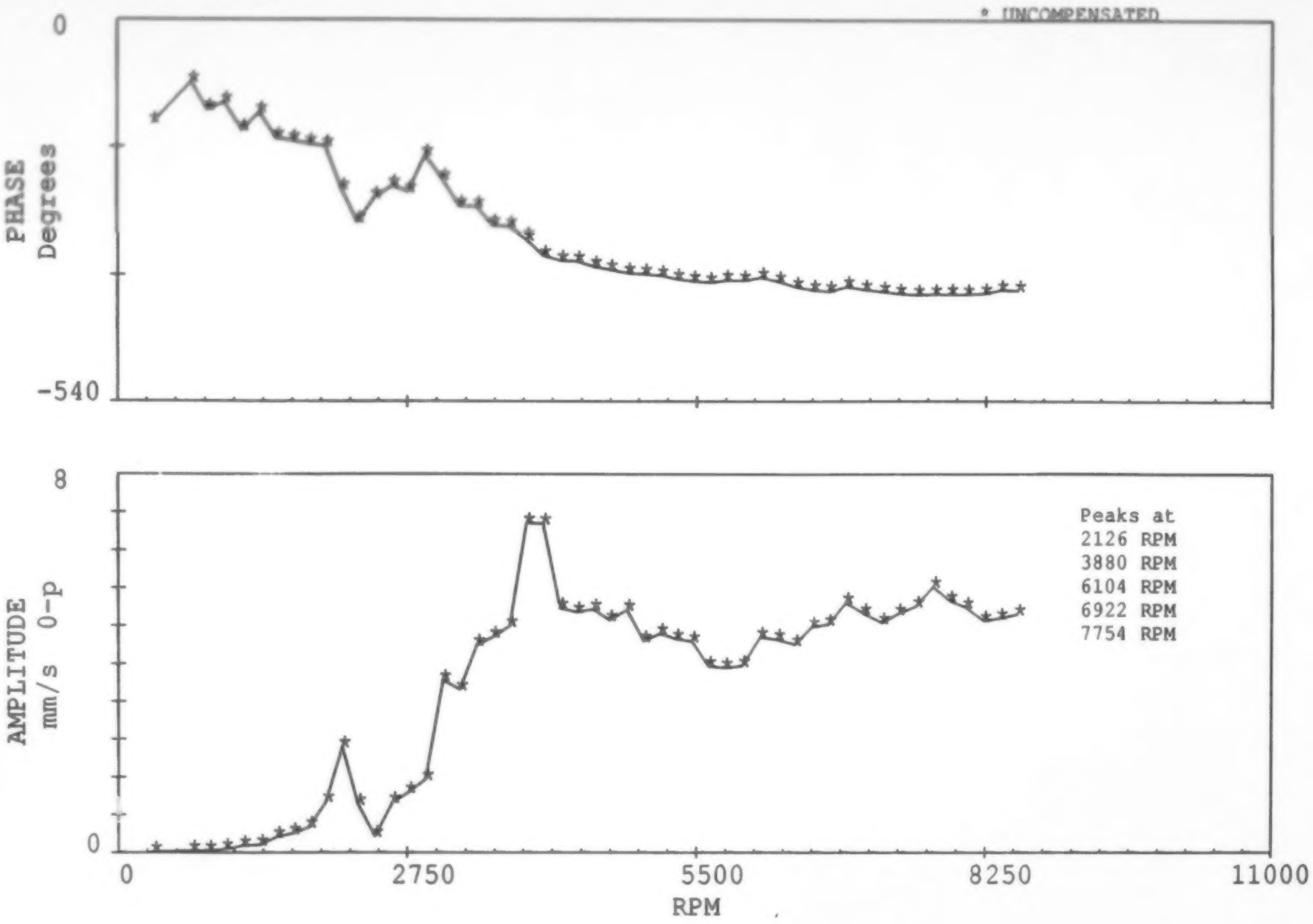


FIGURE G5

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE COLD RUNUP BRG #5 CASING VELOCITY HOR.

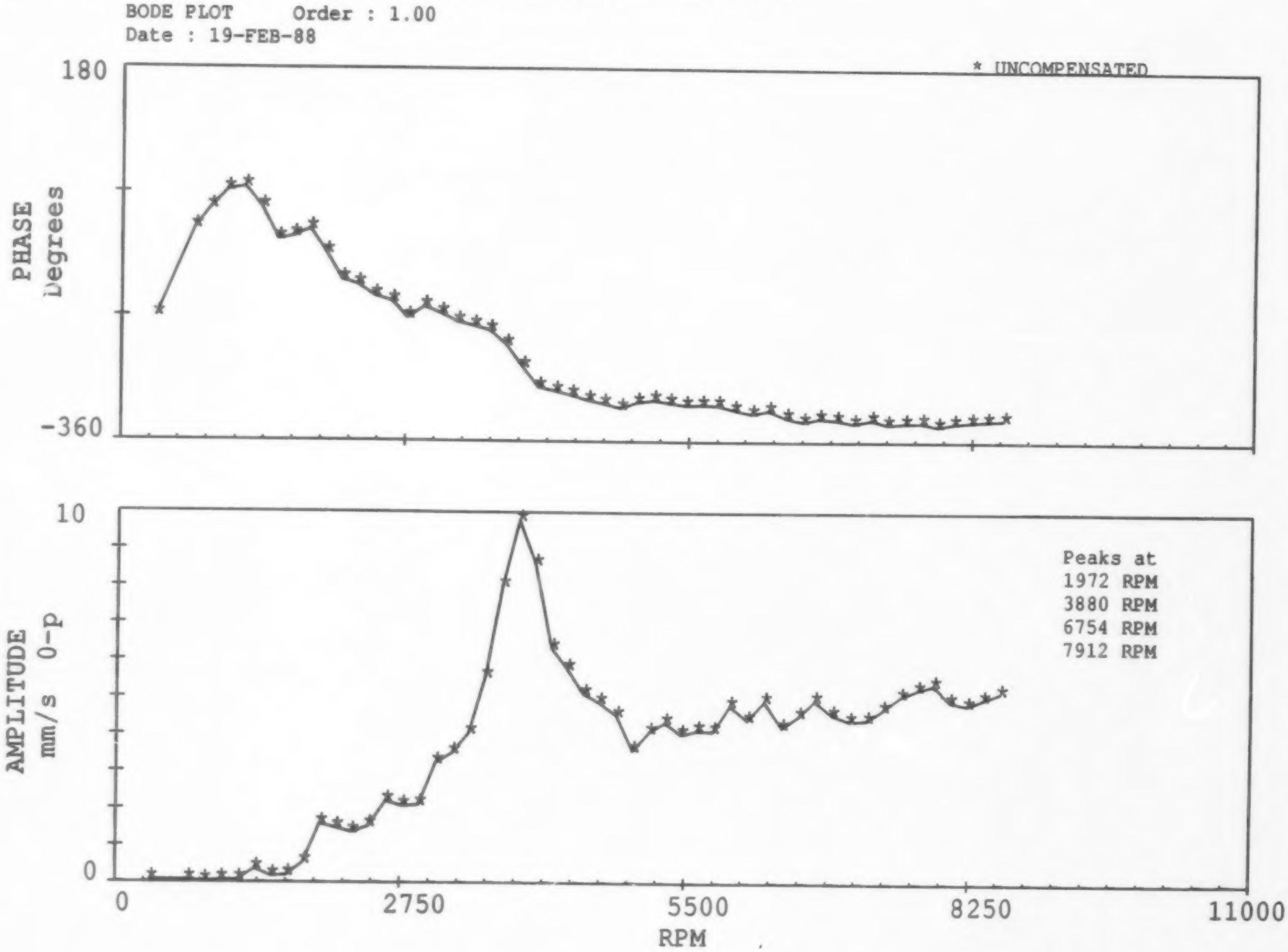


FIGURE G6

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE COLD RUNUP BRG #5 CASING VELOCITY AXIAL

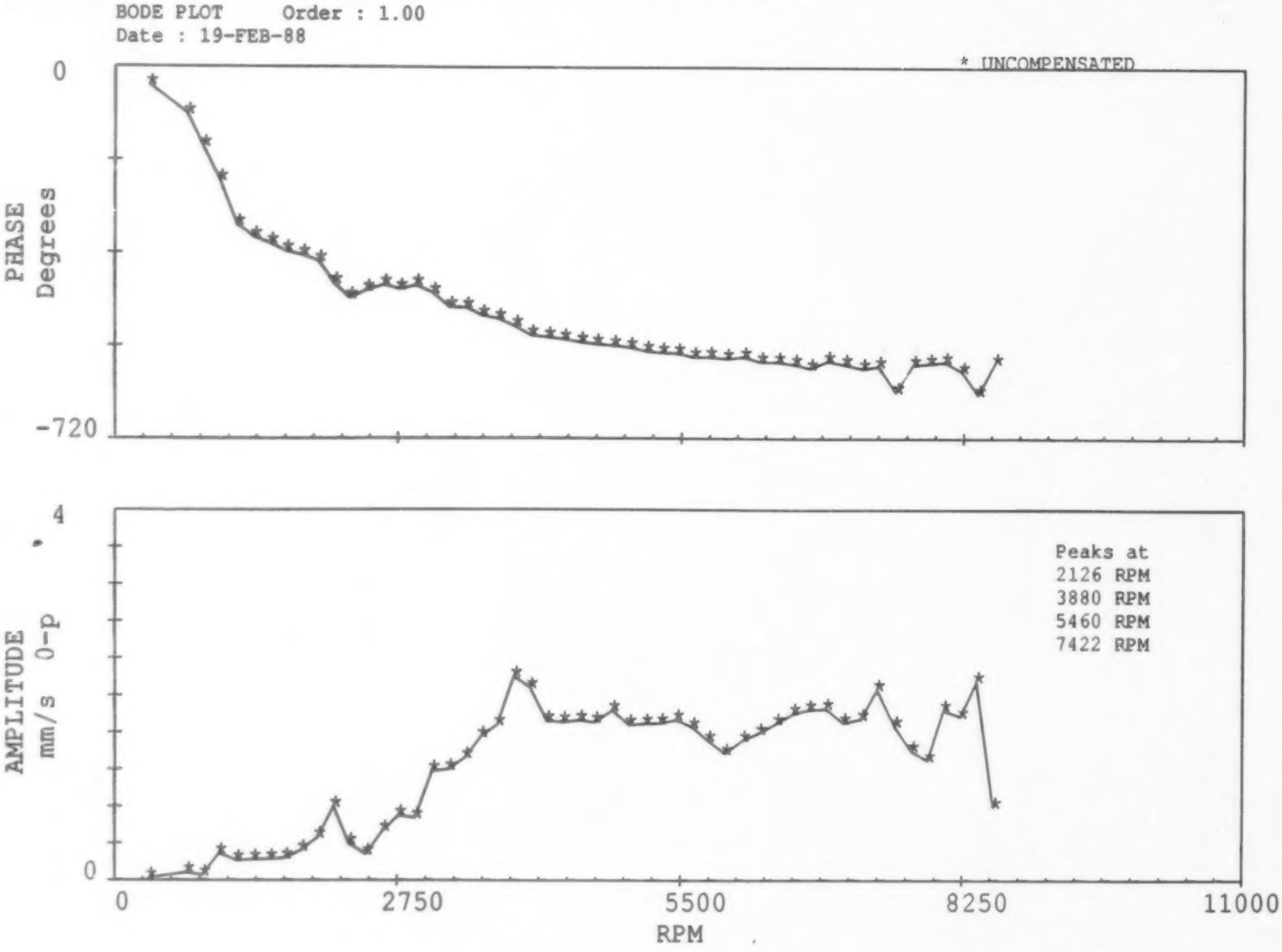


FIGURE G7

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR COLD RUNUP SHAFT DISPLACEMENT OB BRG VERT

BODE PLOT Order : 1.00
Date : 19-FEB-88

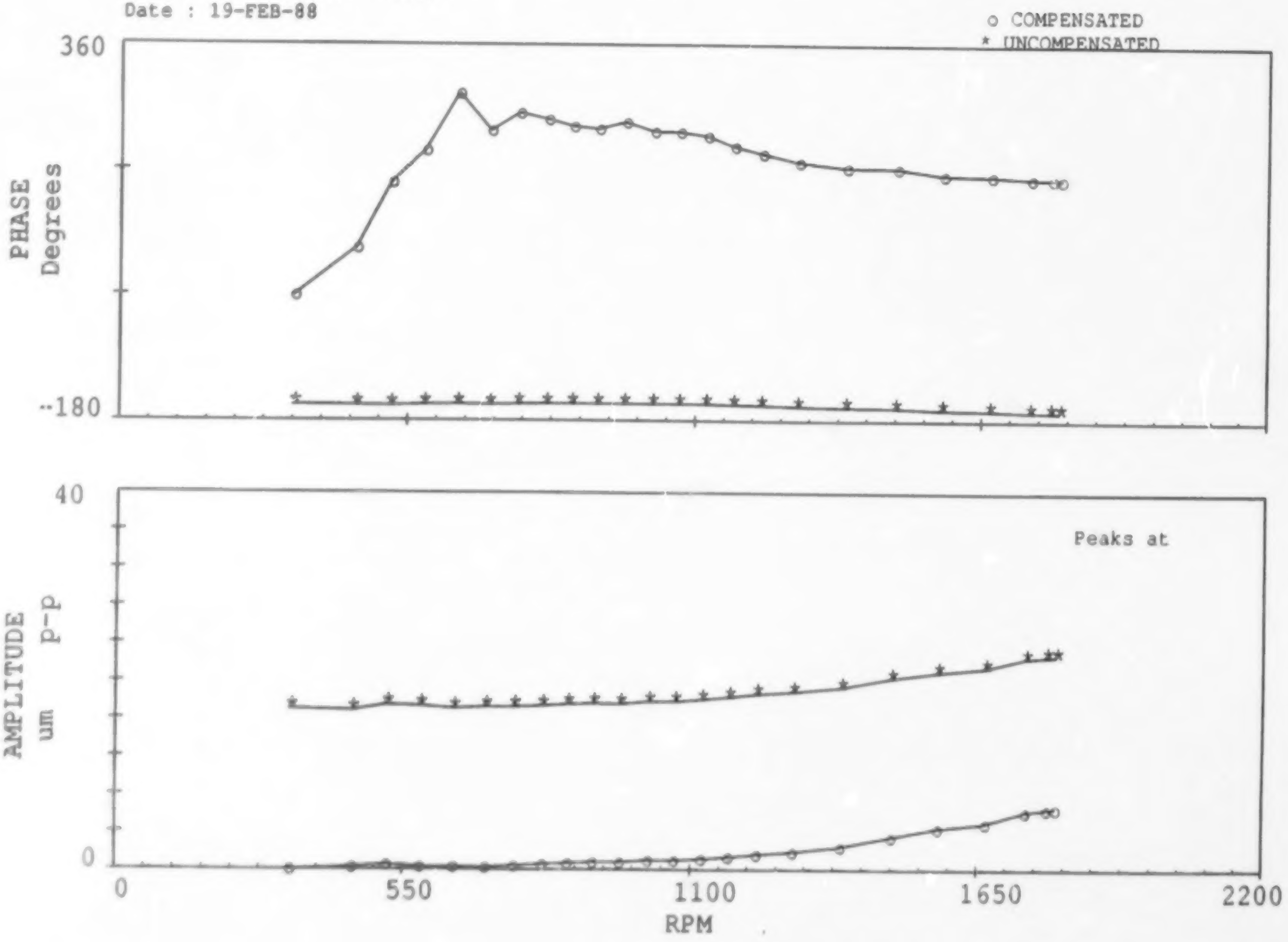


FIGURE G8

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR COLD RUNUP SHAFT DISPLACEMENT OB BRG HOR.

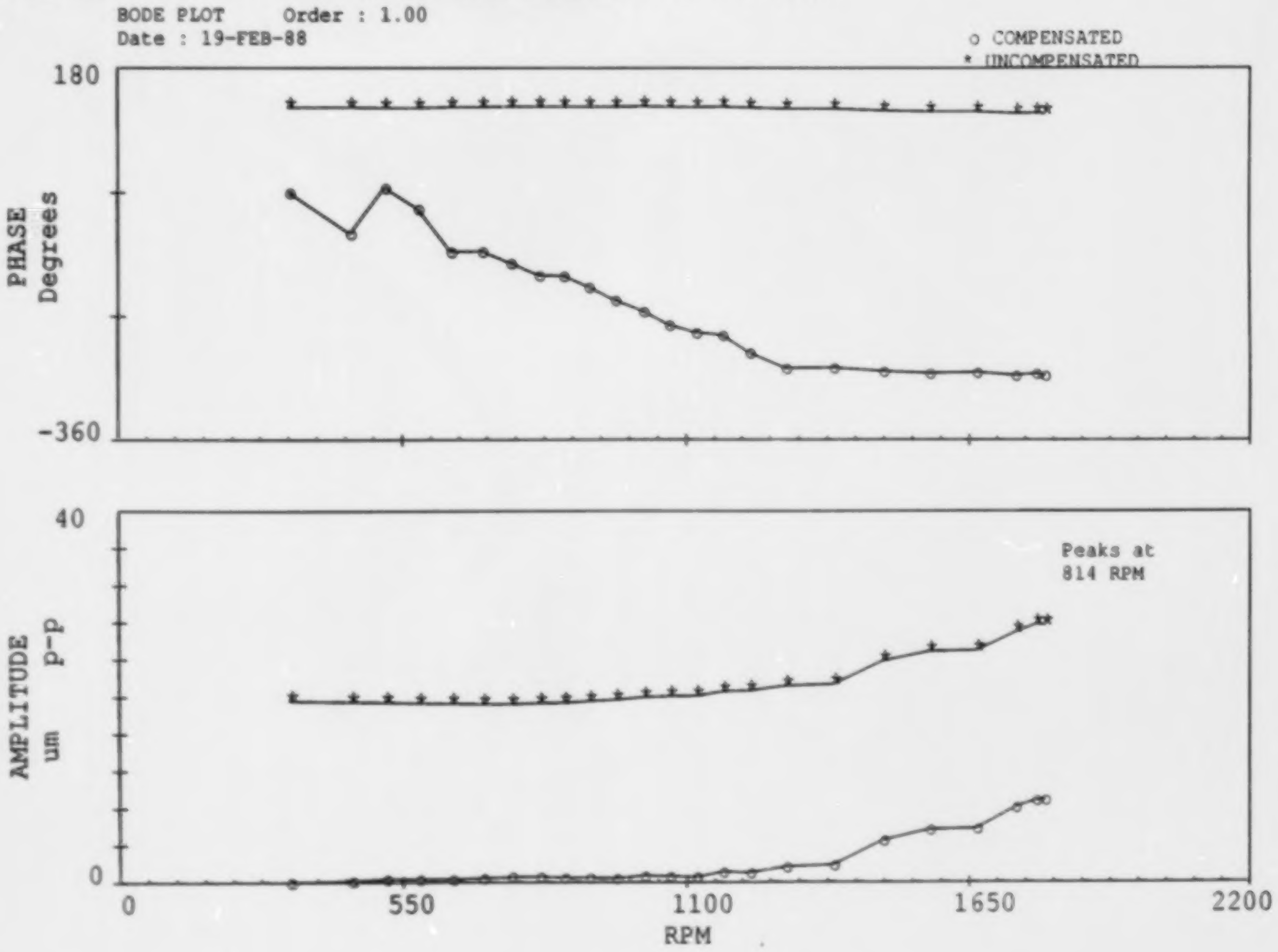


FIGURE G9

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR COLD RUNUP SHAFT DISPLACEMENT IB BRG VERT

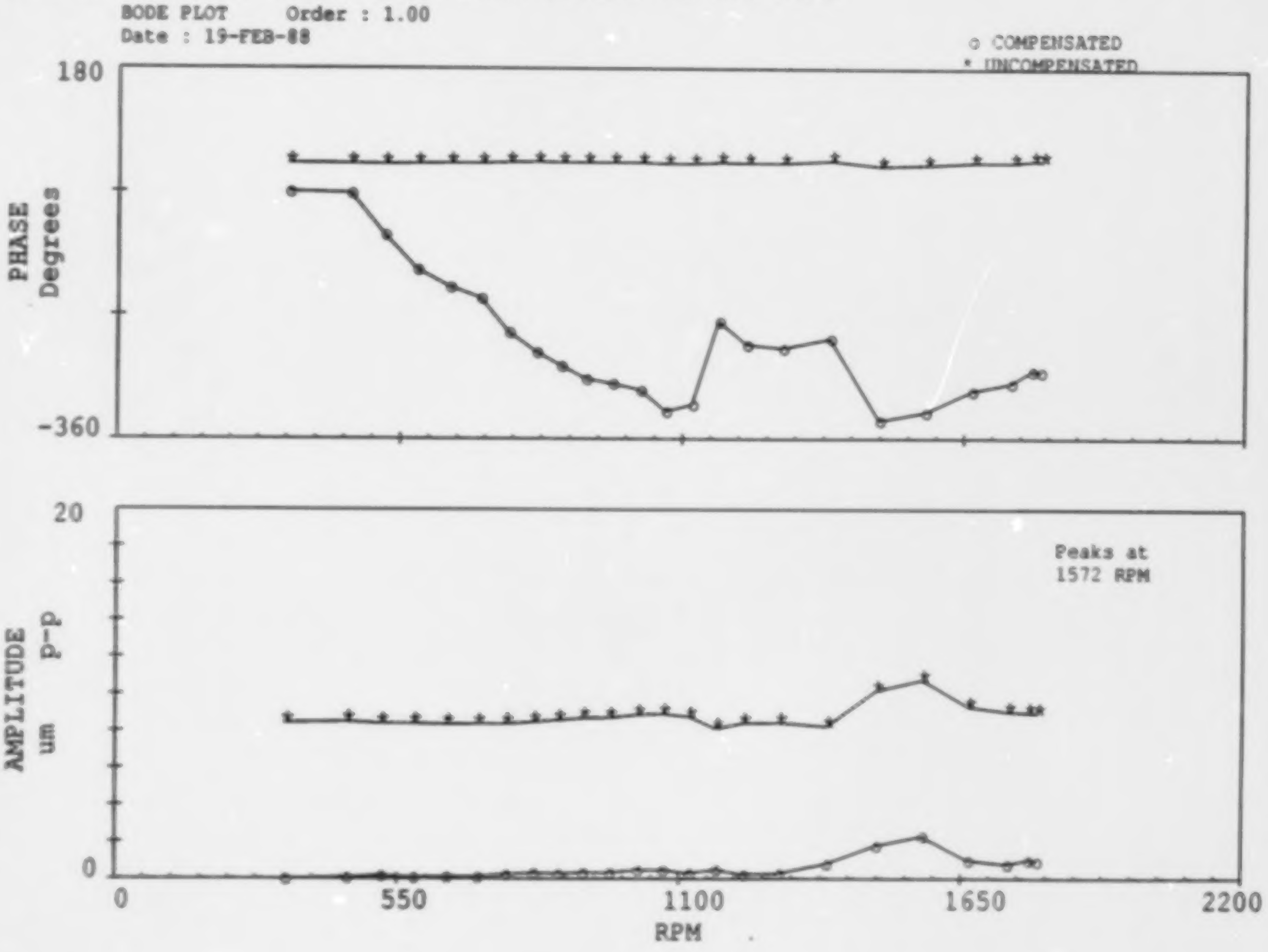


FIGURE G10

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR COLD RUNUP SHAFT DISPLACEMENT IB BRG HOR.

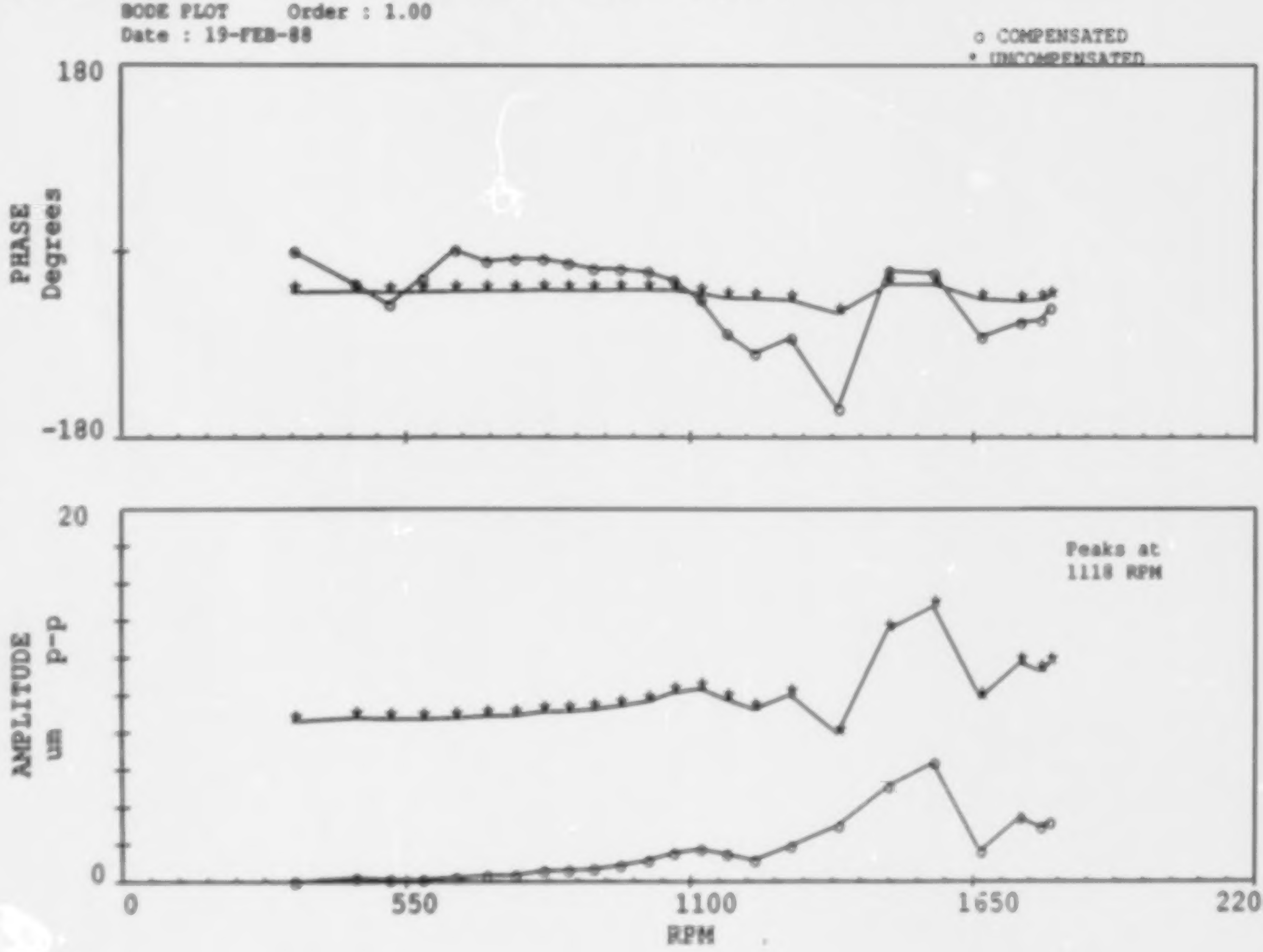


FIGURE G11

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE COLD RUNUP BRG #4 SHAFT DISPLACEMENT VERT

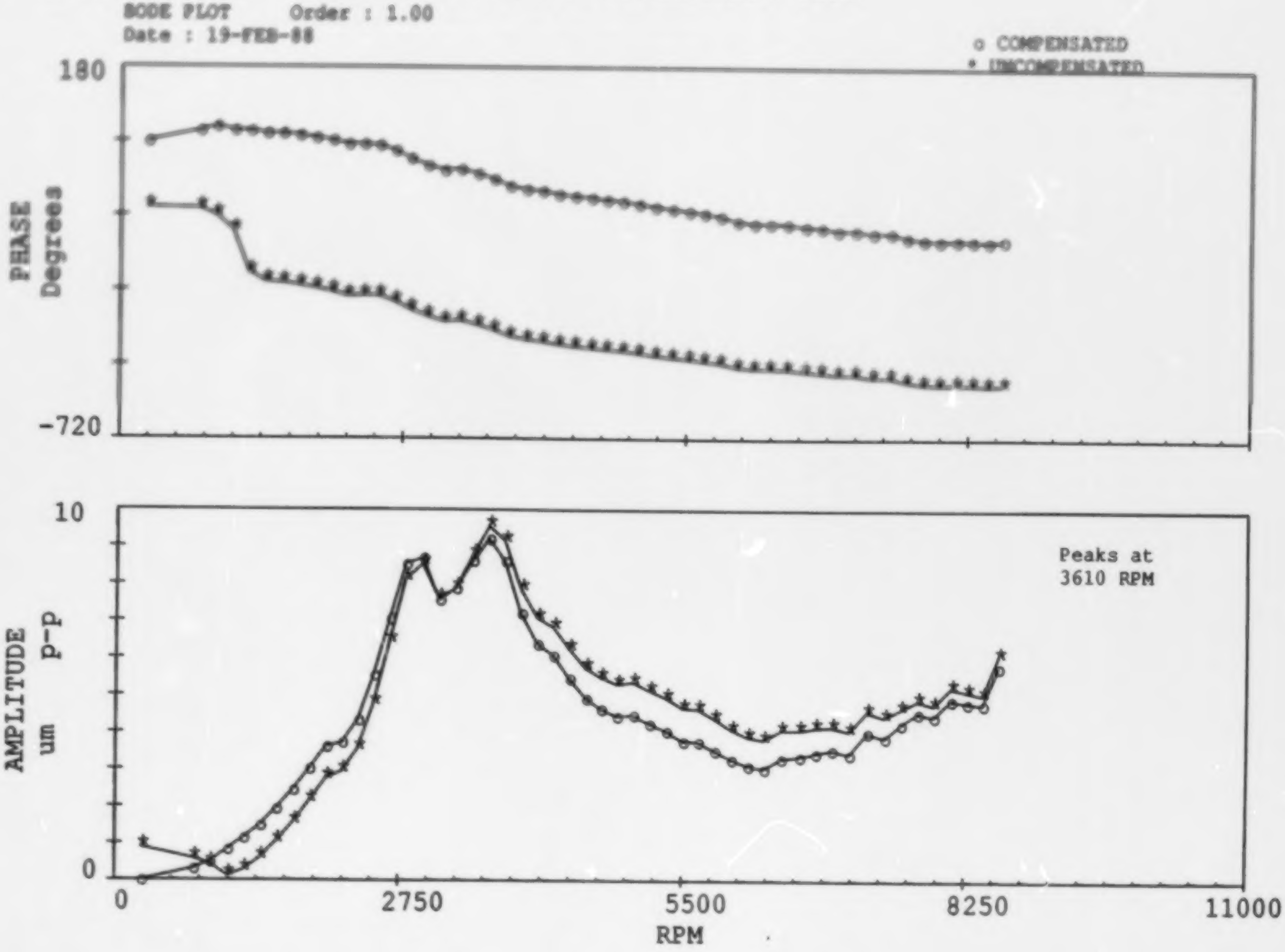


FIGURE G12

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE COLD RUNUP BRG #4 SHAFT DISPLACEMENT HOR.

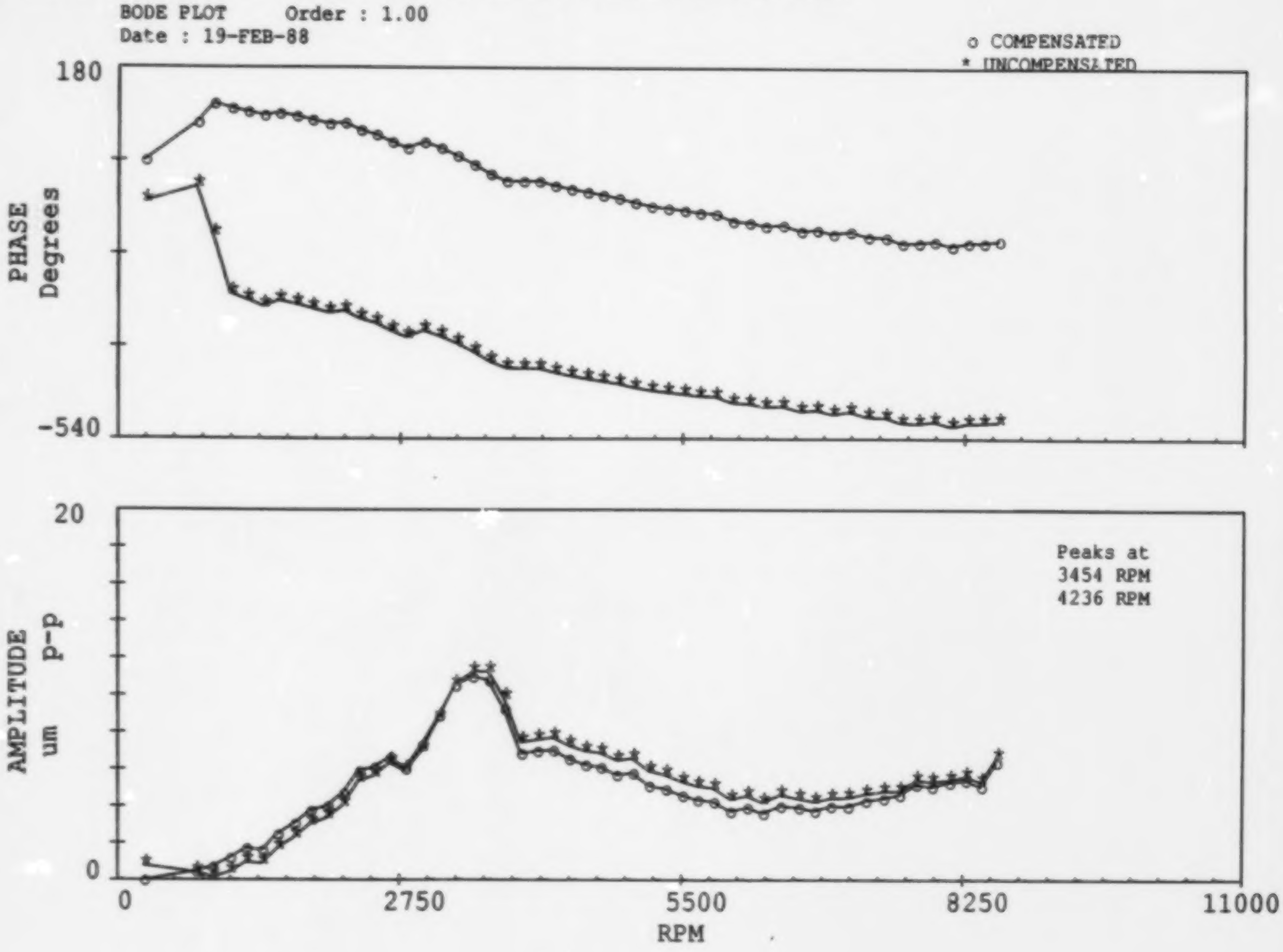


FIGURE G13

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE COLD RUNUP BRG #5 SHAFT DISPLACEMENT VERT

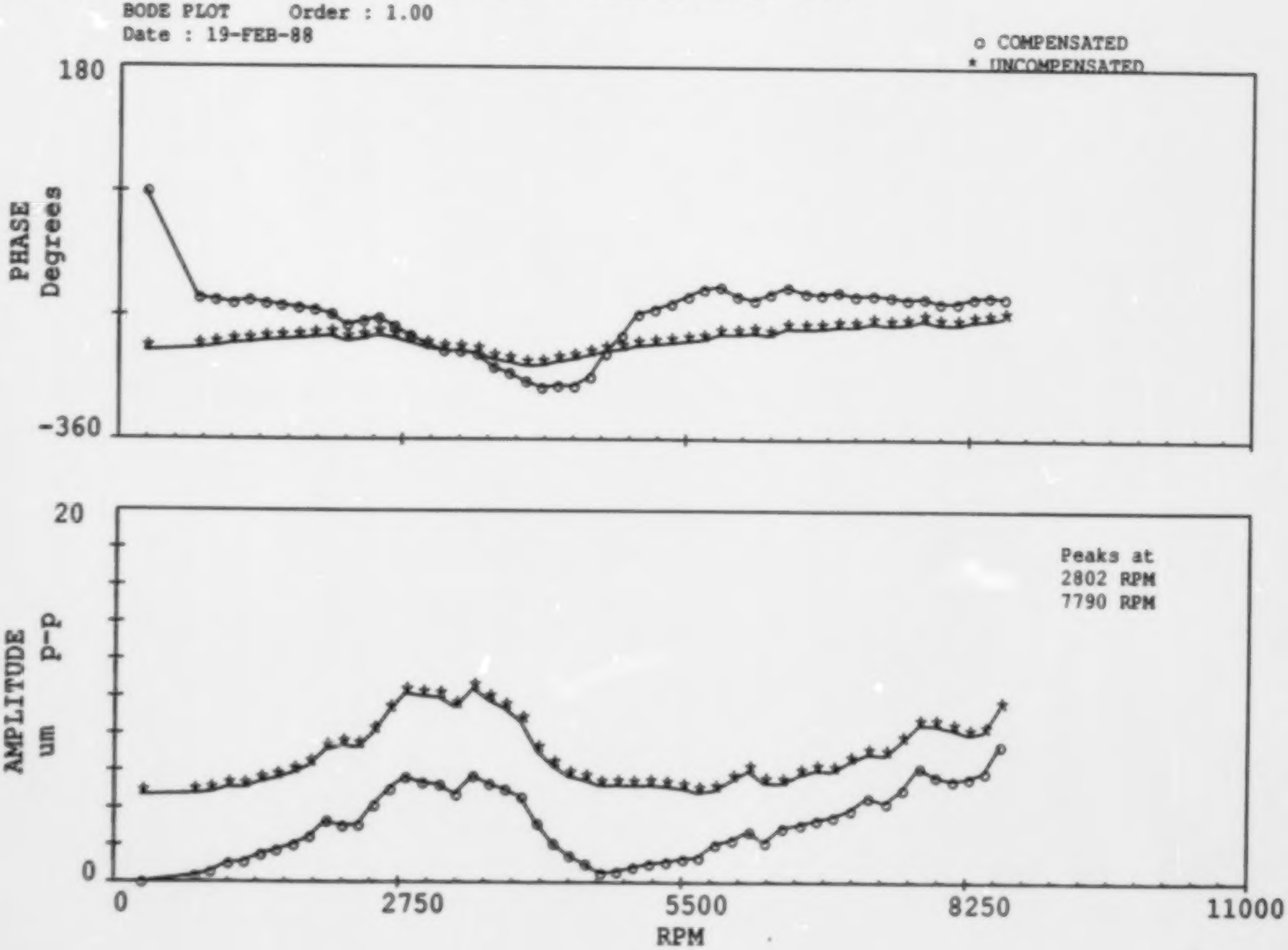


FIGURE G14

90-310

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE COLD RUNUP BRG #5 SHAFT DISPLACEMENT HOR.

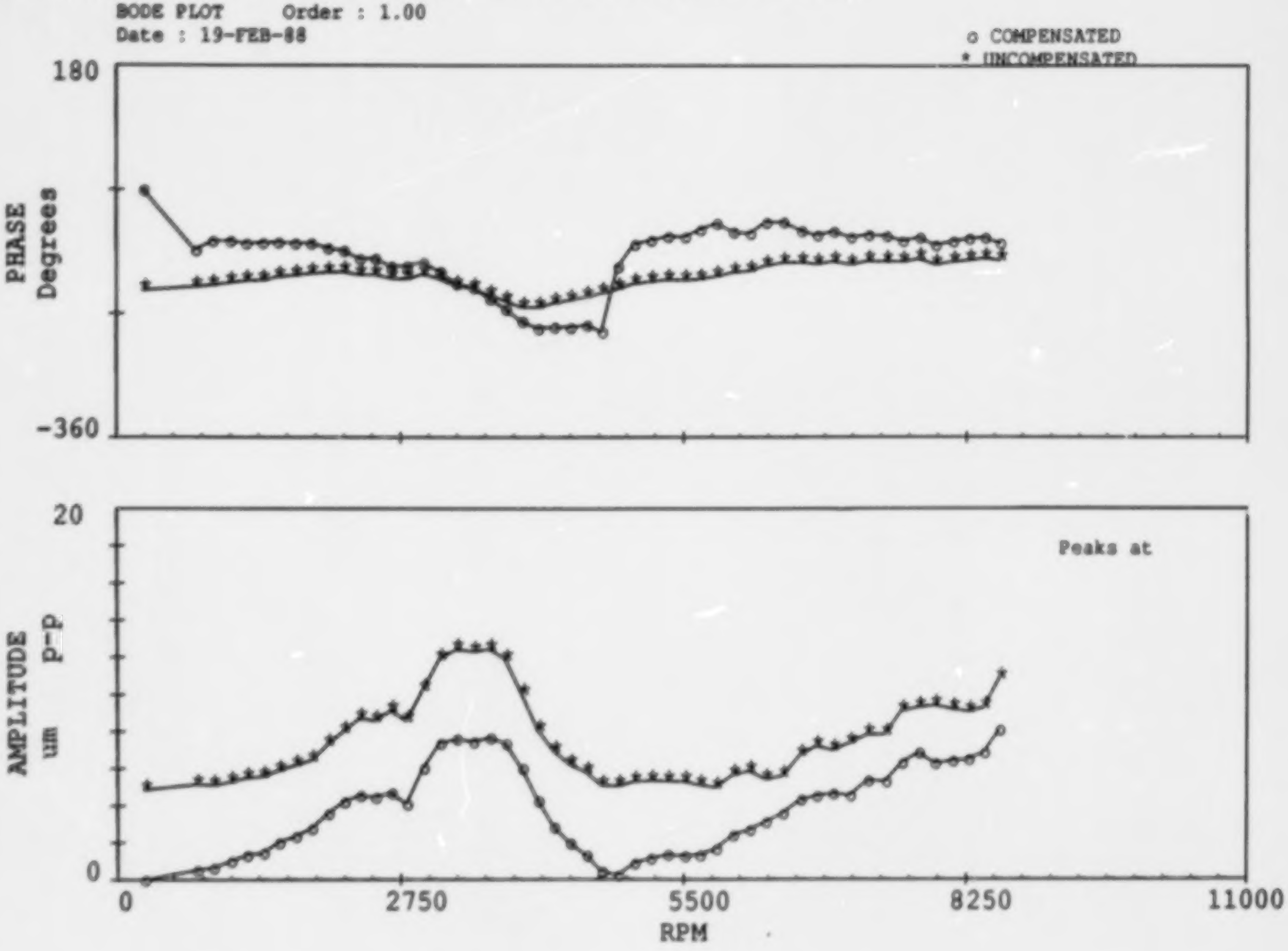


FIGURE G15

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR COLD RUNUP BRG #1 SHAFT DISPLACEMENT VERT

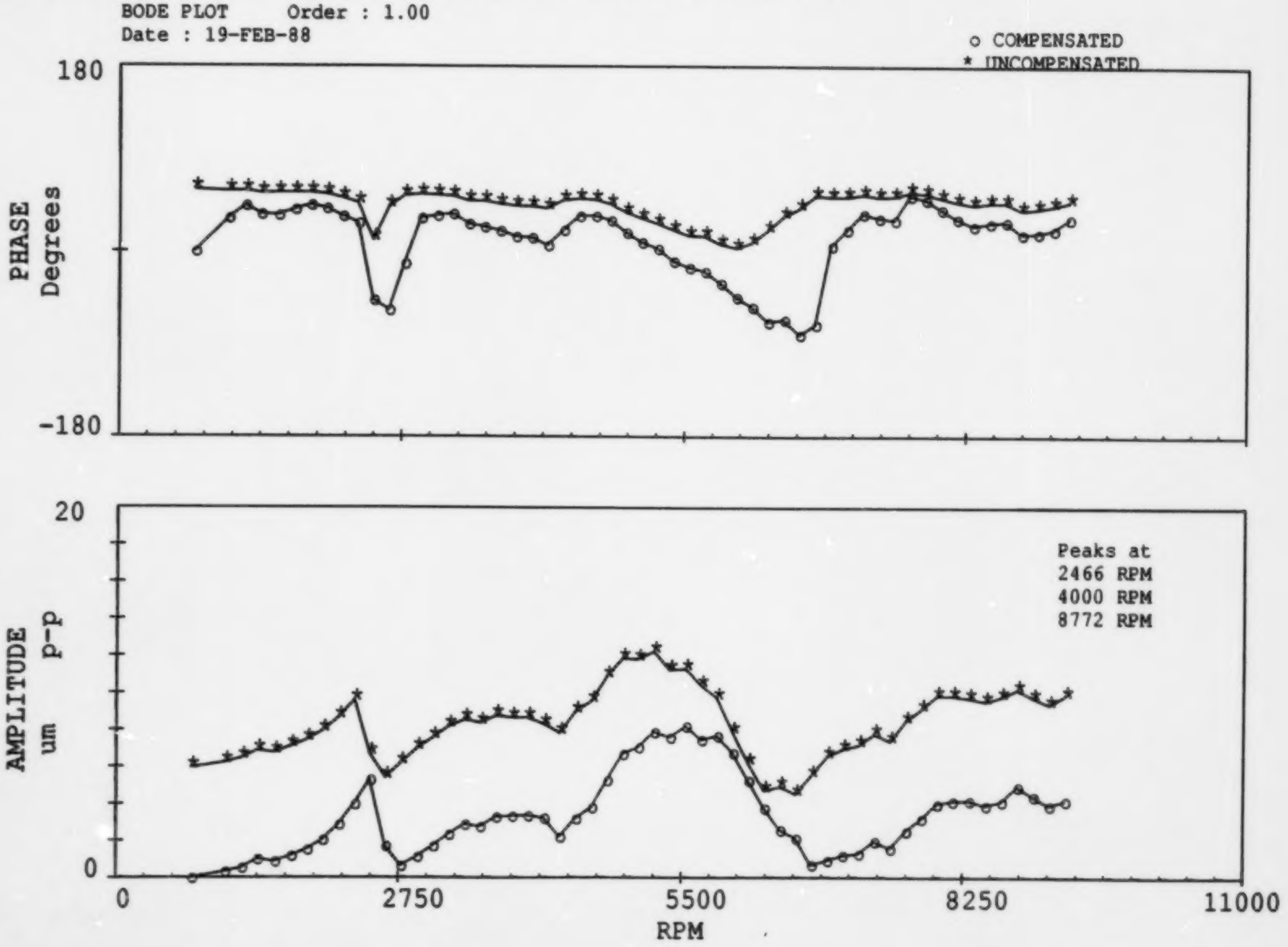


FIGURE G16

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR COLD RUNUP BRG #1 SHAFT DISPLACEMENT HOR.

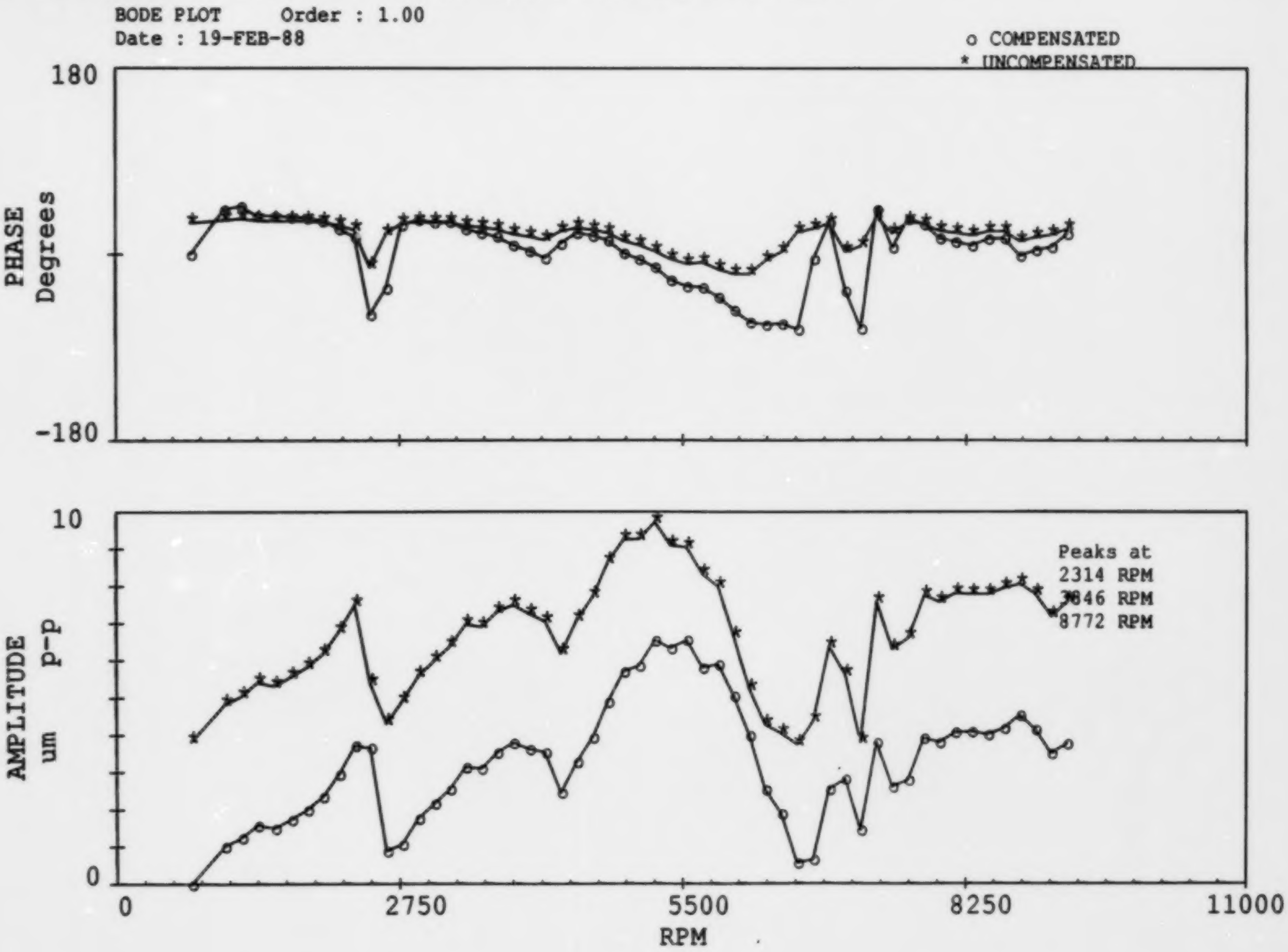


FIGURE G17

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR COLD RUNUP BRG #2 SHAFT DISPLACEMENT VERT

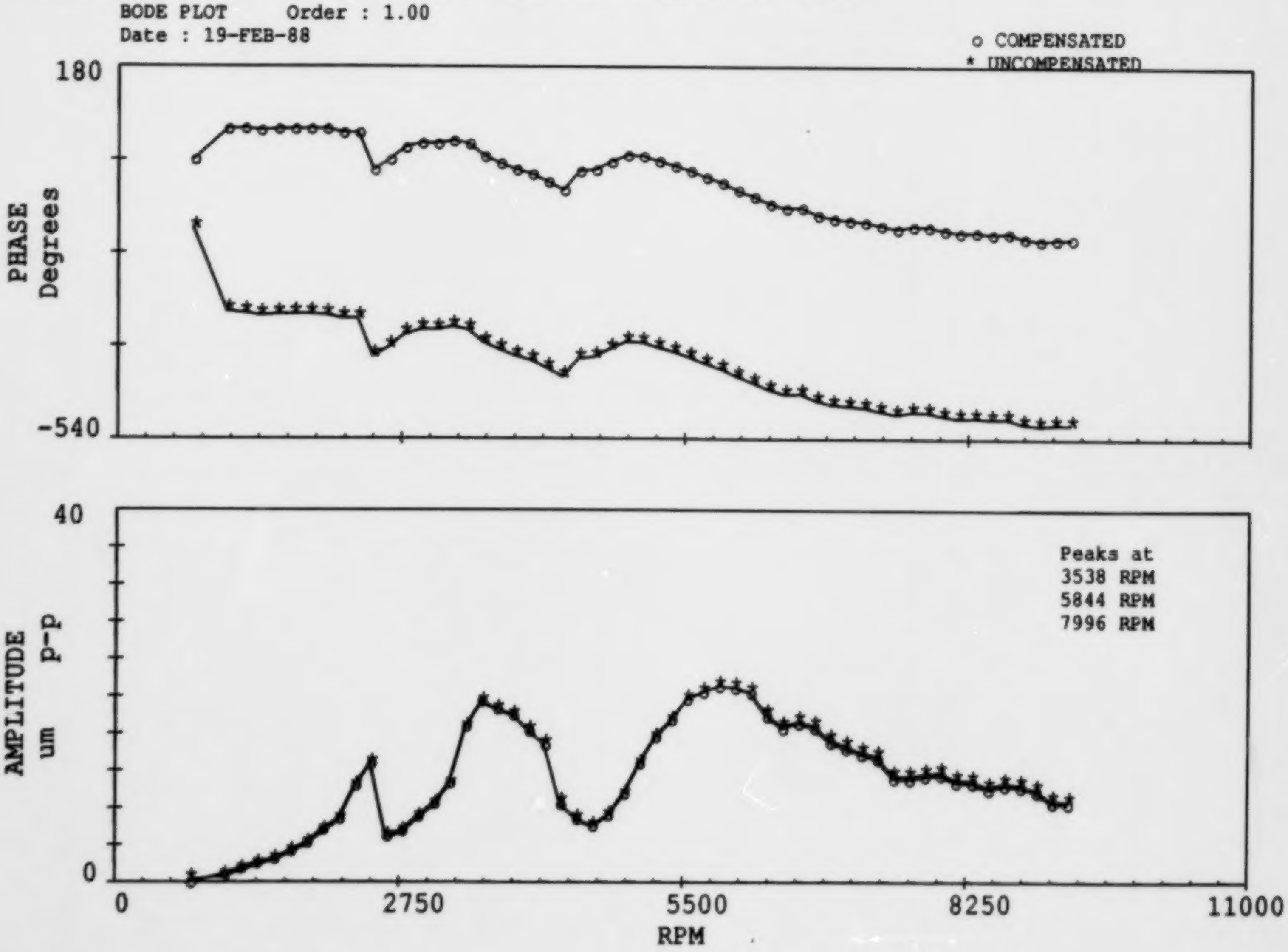


FIGURE G18

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR COLD RUNUP BRG #2 SHAFT DISPLACEMENT HOR.

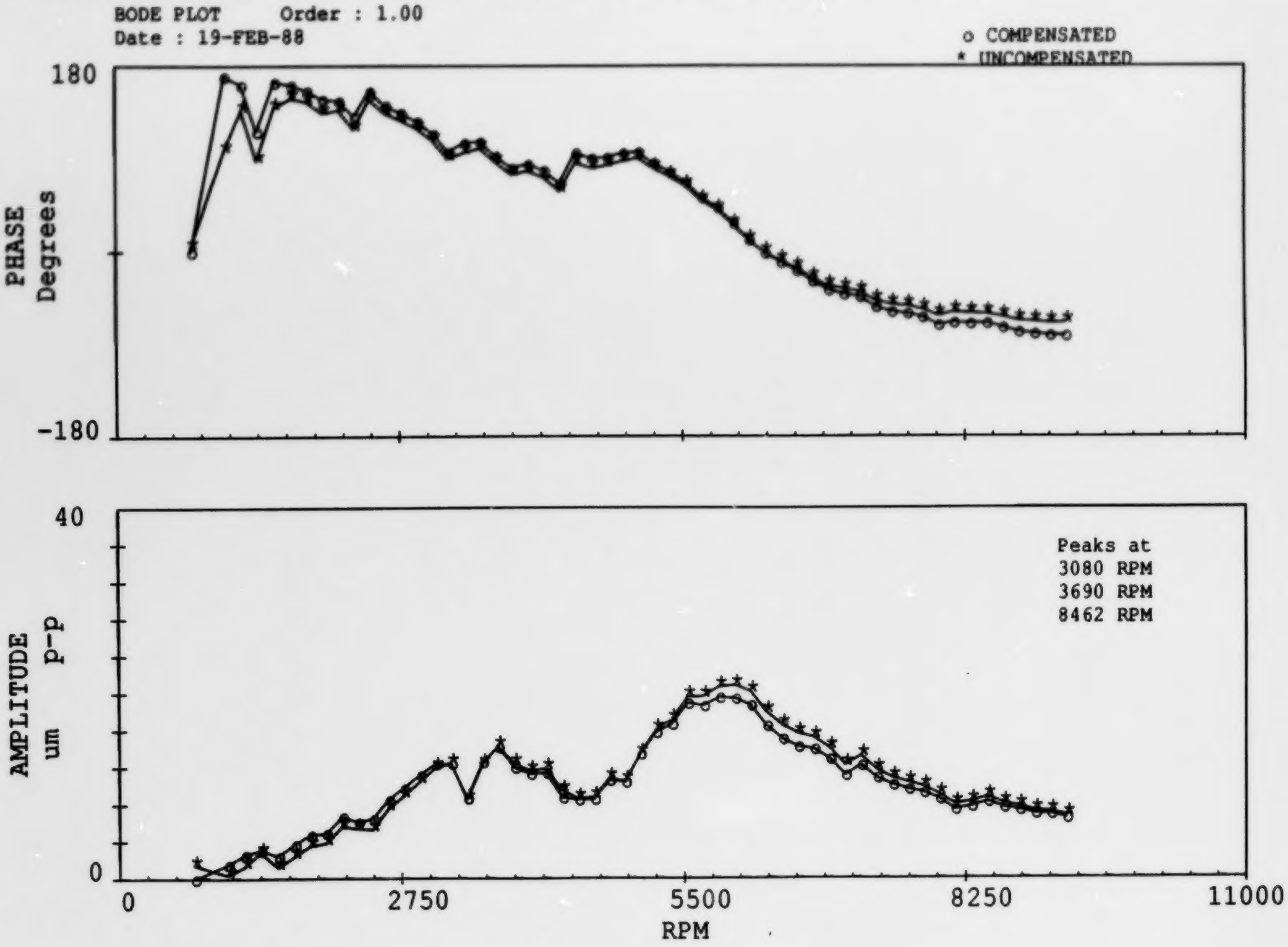


FIGURE G19

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR COLD RUNUP BRG #3 SHAFT DISPLACEMENT VERT

BODE PLOT Order : 1.00
Date : 19-FEB-88

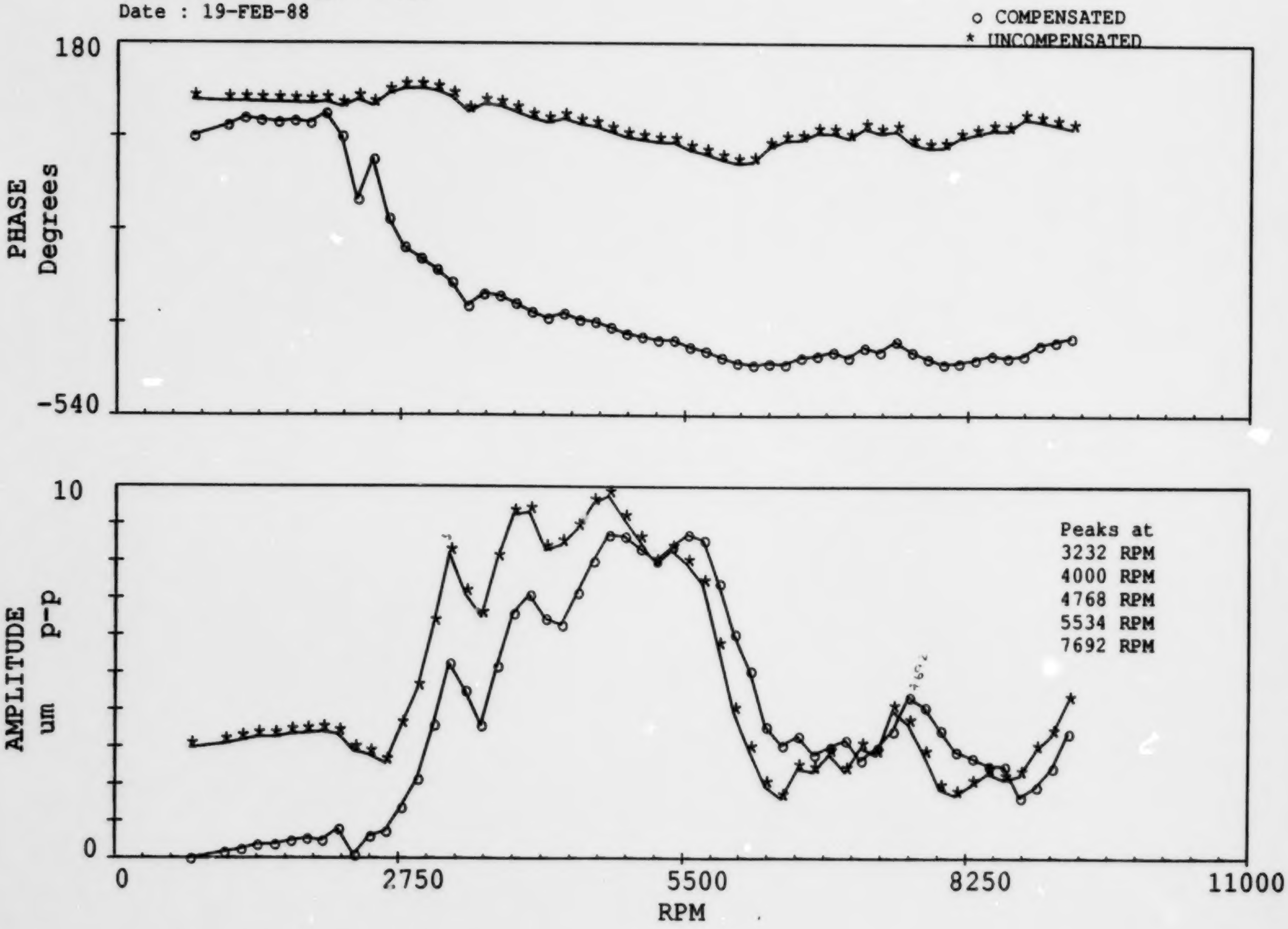


FIGURE G20

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR COLD RUNUP BRG #3 SHAFT DISPLACEMENT HOR.

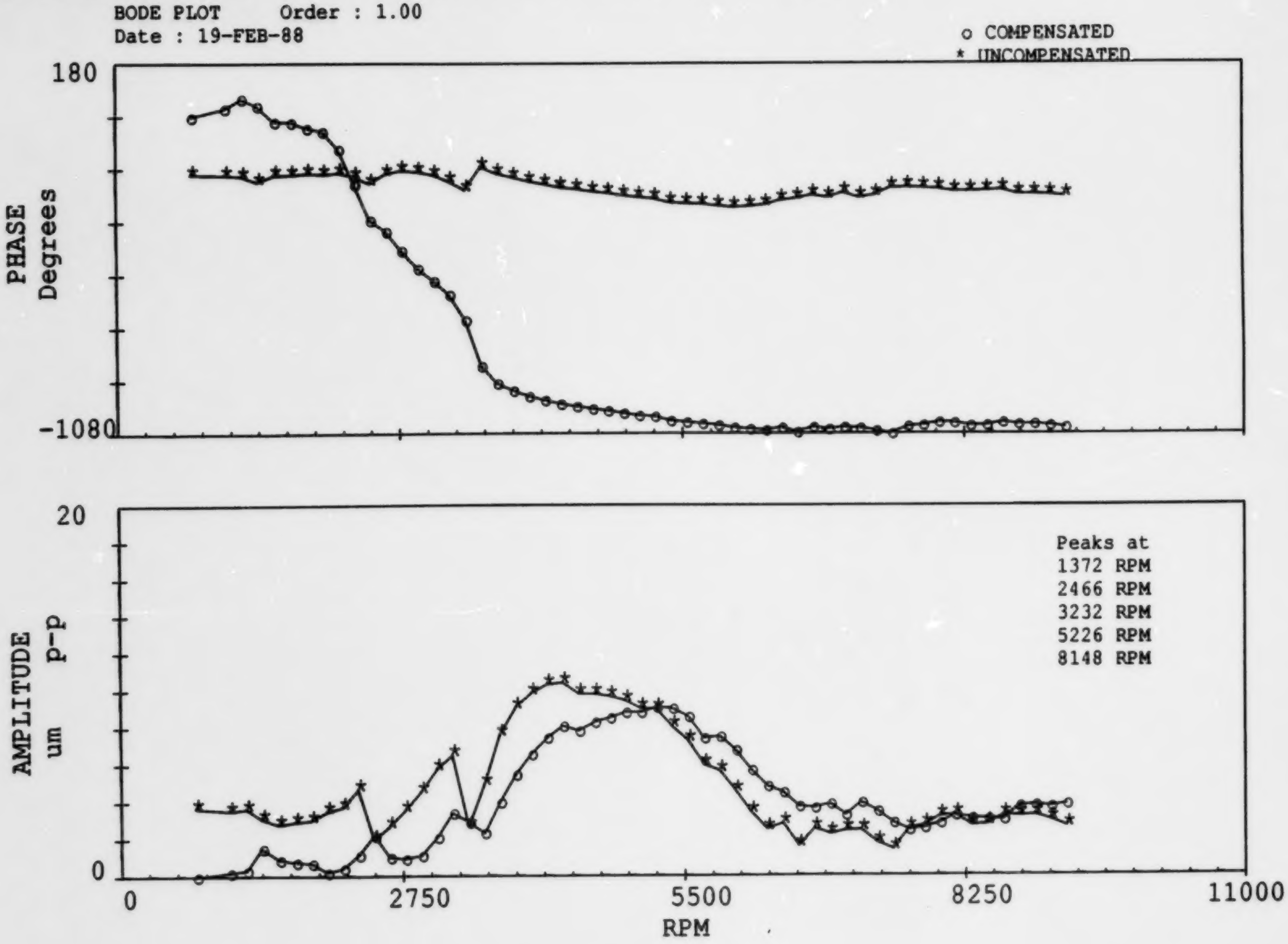


FIGURE G21

APPENDIX H

BODE PLOTS OF VIBRATION DURING HOT RUNDOWN

TABLE H1
DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
FIGURE NUMBERS FOR BODE PLOTS OF VIBRATION DURING HOT RUNDOWN

Measurement	Figure No of Bode Plot
AC Generator Outboard Bearing Casing Velocity - Vertical Direction	H1
- Horizontal Direction	H2
AC Generator Inboard Bearing Casing Velocity - Vertical Direction	H3
- Horizontal Direction	H4
Power Turbine Bearing No 5 Casing Velocity - Vertical Direction	H5
- Horizontal Direction	H6
- Axial Direction	H7
AC Generator Outboard Bearing Shaft Displacement - Vertical Direction	H8
- Horizontal Direction	H9
AC Generator Inboard Bearing Shaft Displacement - Vertical Direction	H10
- Horizontal Direction	H11
Power Turbine Bearing No 4 Shaft Displacement - Vertical Direction	H12
- Horizontal Direction	H13
Power Turbine Bearing No 5 Shaft Displacement - Vertical Direction	H14
- Horizontal Direction	H15
Gas Producer Bearing No 1 Shaft Displacement - Vertical Direction	H16
- Horizontal Direction	H17
Gas Producer Bearing No 2 Shaft Displacement - Vertical Direction	H18
- Horizontal Direction	H19
Gas Producer Bearing No 3 Shaft Displacement - Vertical Direction	H20
- Horizontal Direction	H21

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR HOT RUNDOWN OB BRG CASING VELOCITY VERT.

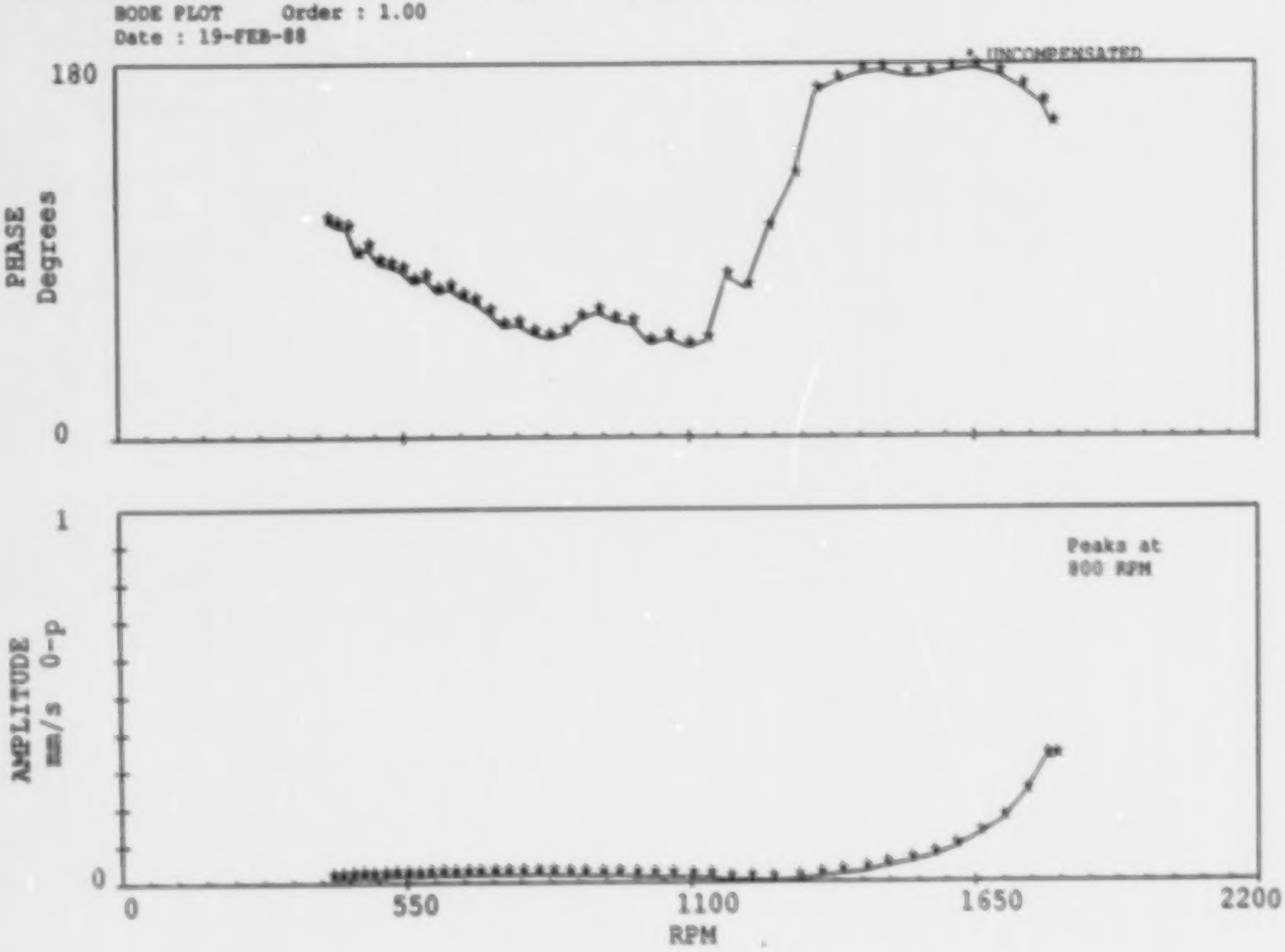


FIGURE H1

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR HOT RUNDOWN OB BRG CASING VELOCITY HOR.

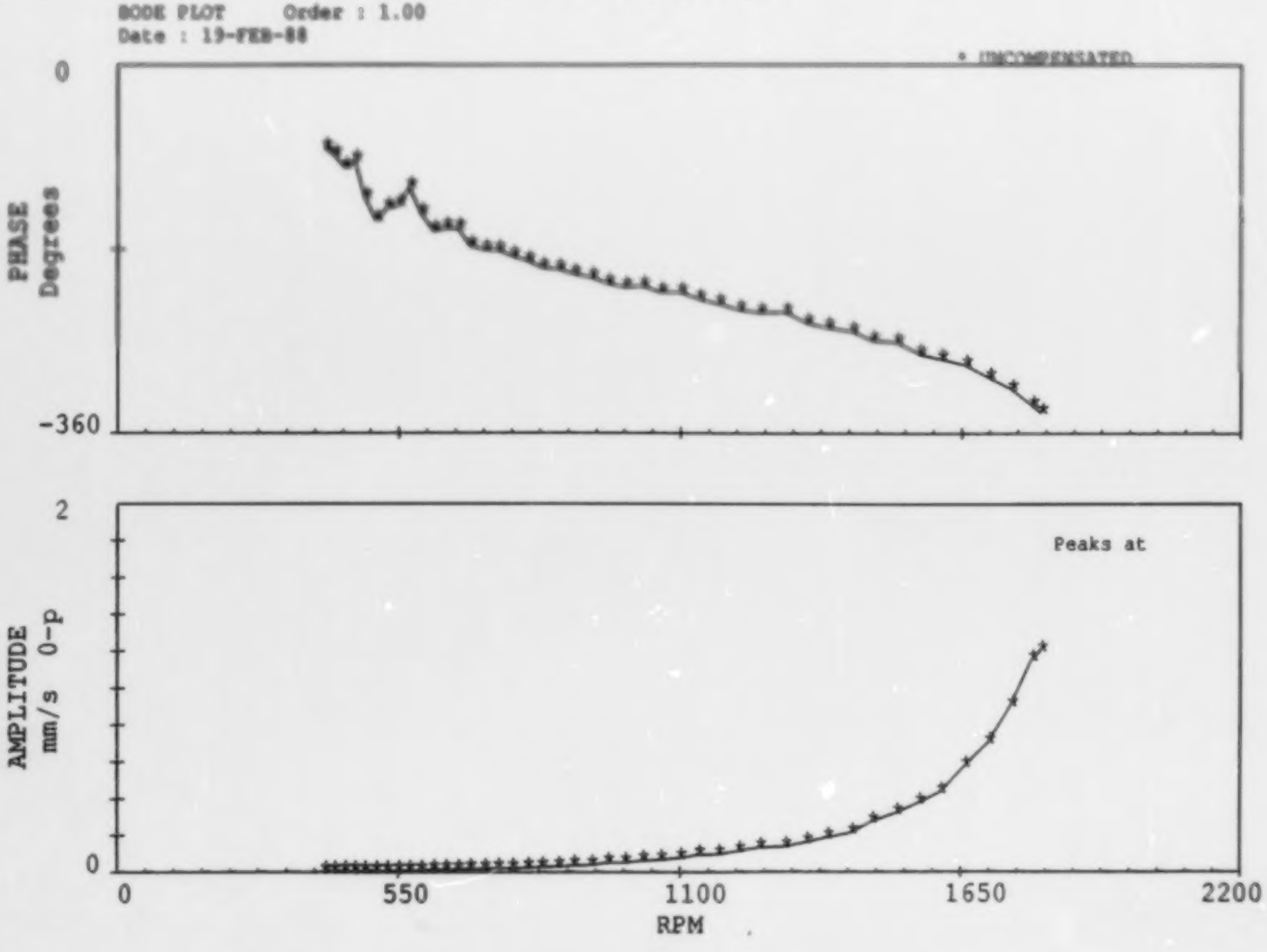


FIGURE H2

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR HOT RUNDOWN IB BRG CASING VELOCITY VERT.

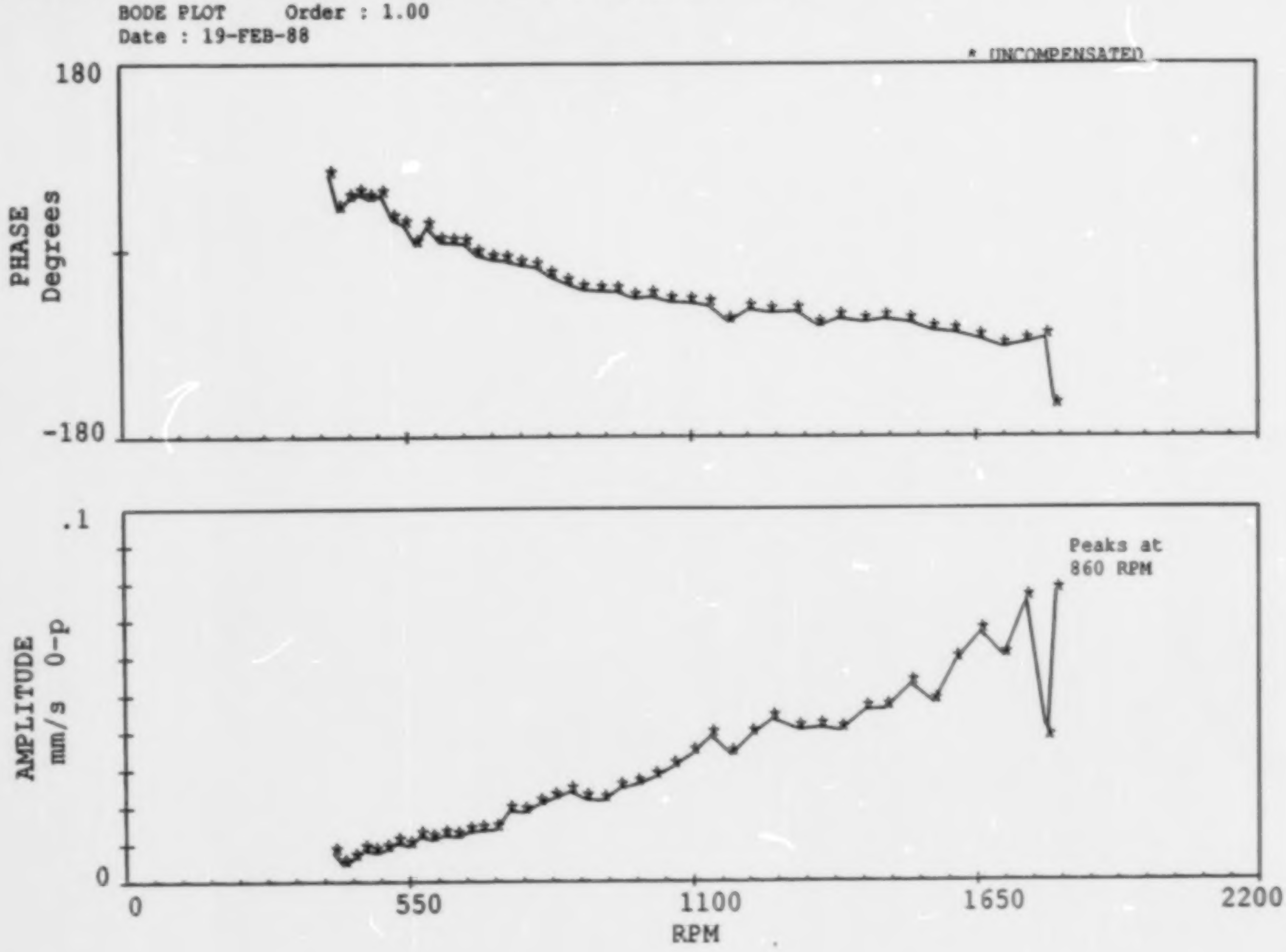


FIGURE H3

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR HOT RUNDOWN IB BRG CASING VELOCITY HOR.

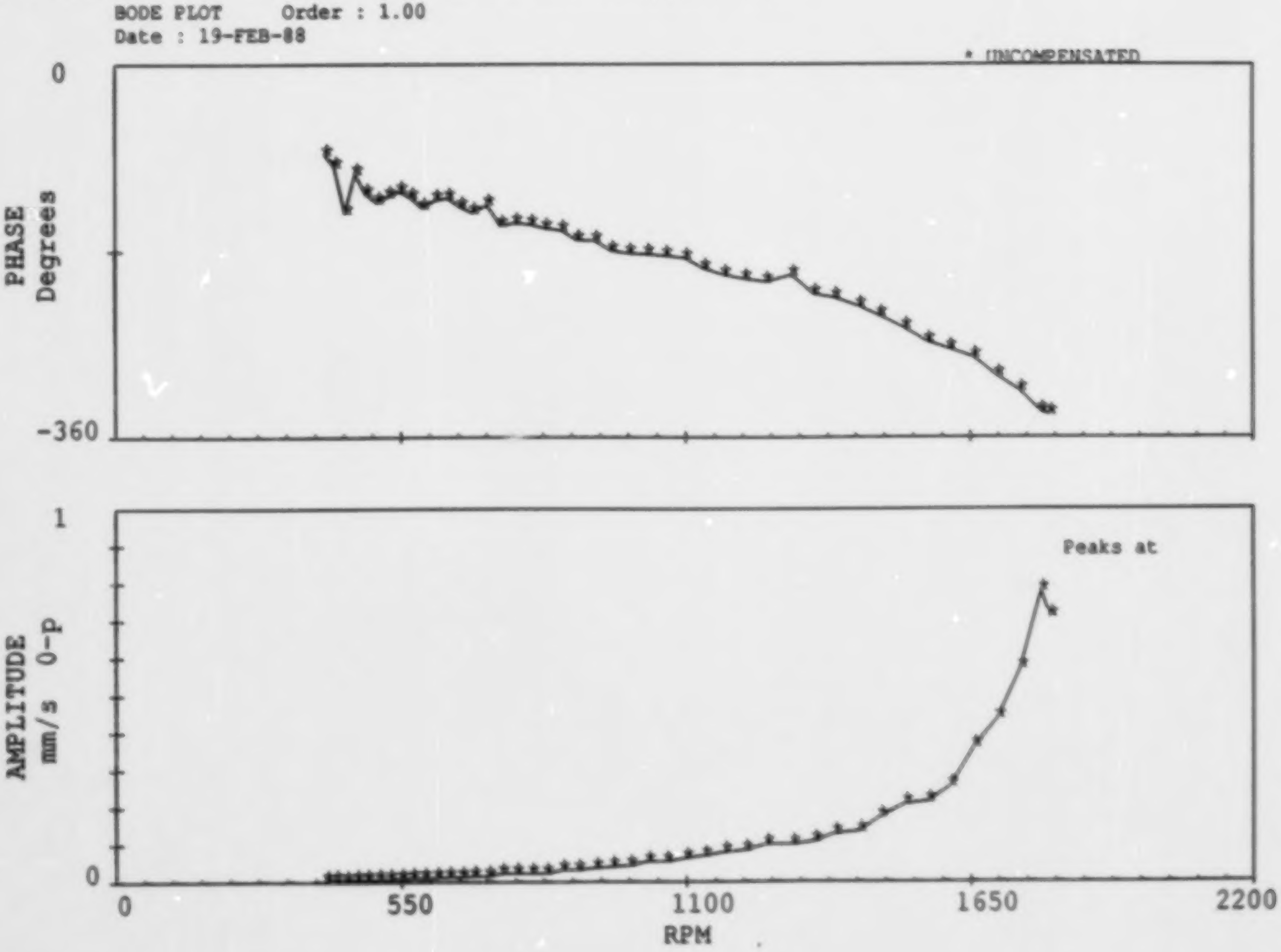


FIGURE H4

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE HOT RUNDOWN BRG #5 CASING VELOCITY VERT.

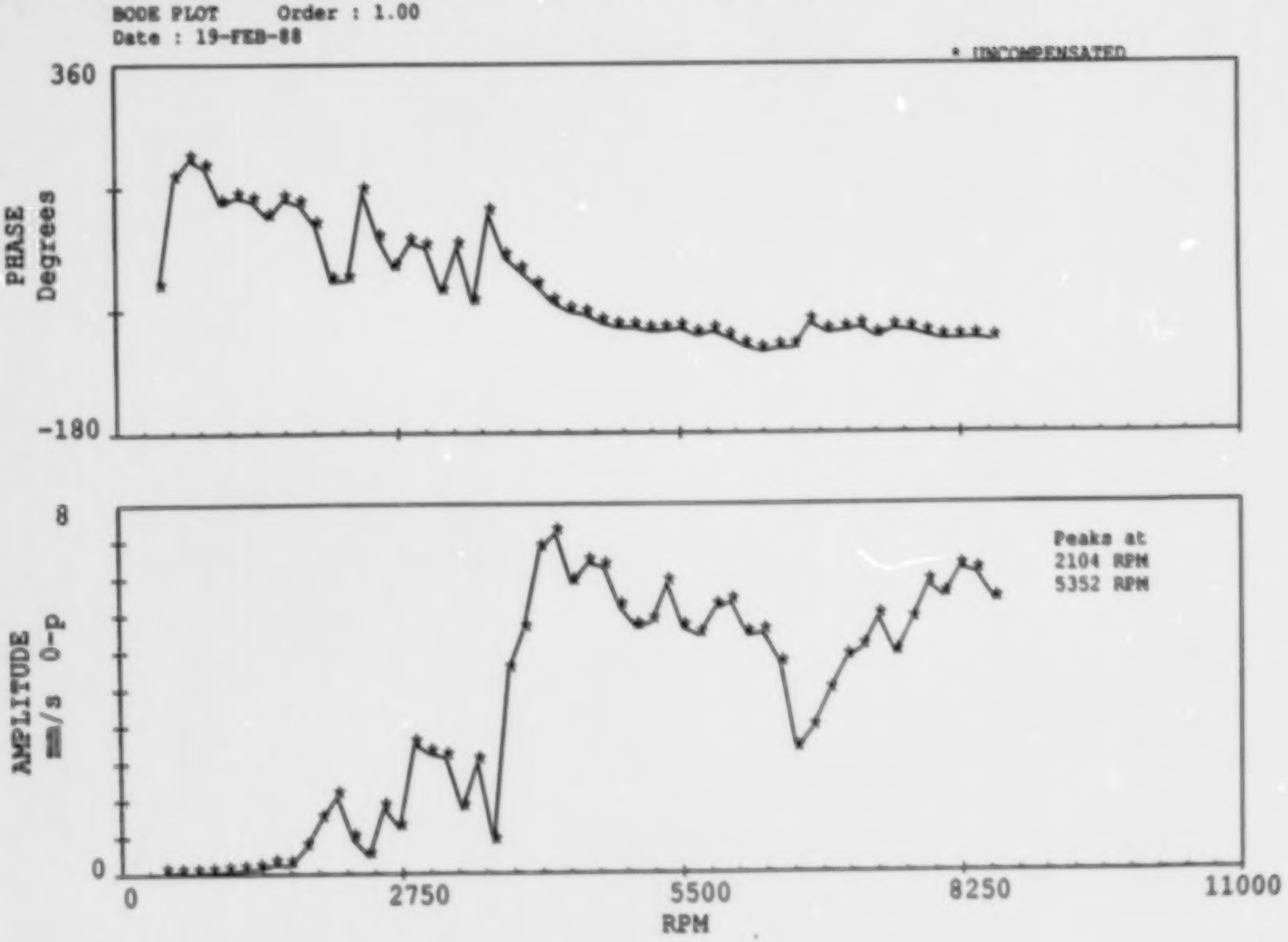


FIGURE H5

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE HOT RUNDOWN BRG #5 CASING VELOCITY HOR.

BODE PLOT Order : 1.00
Date : 19-FEB-88

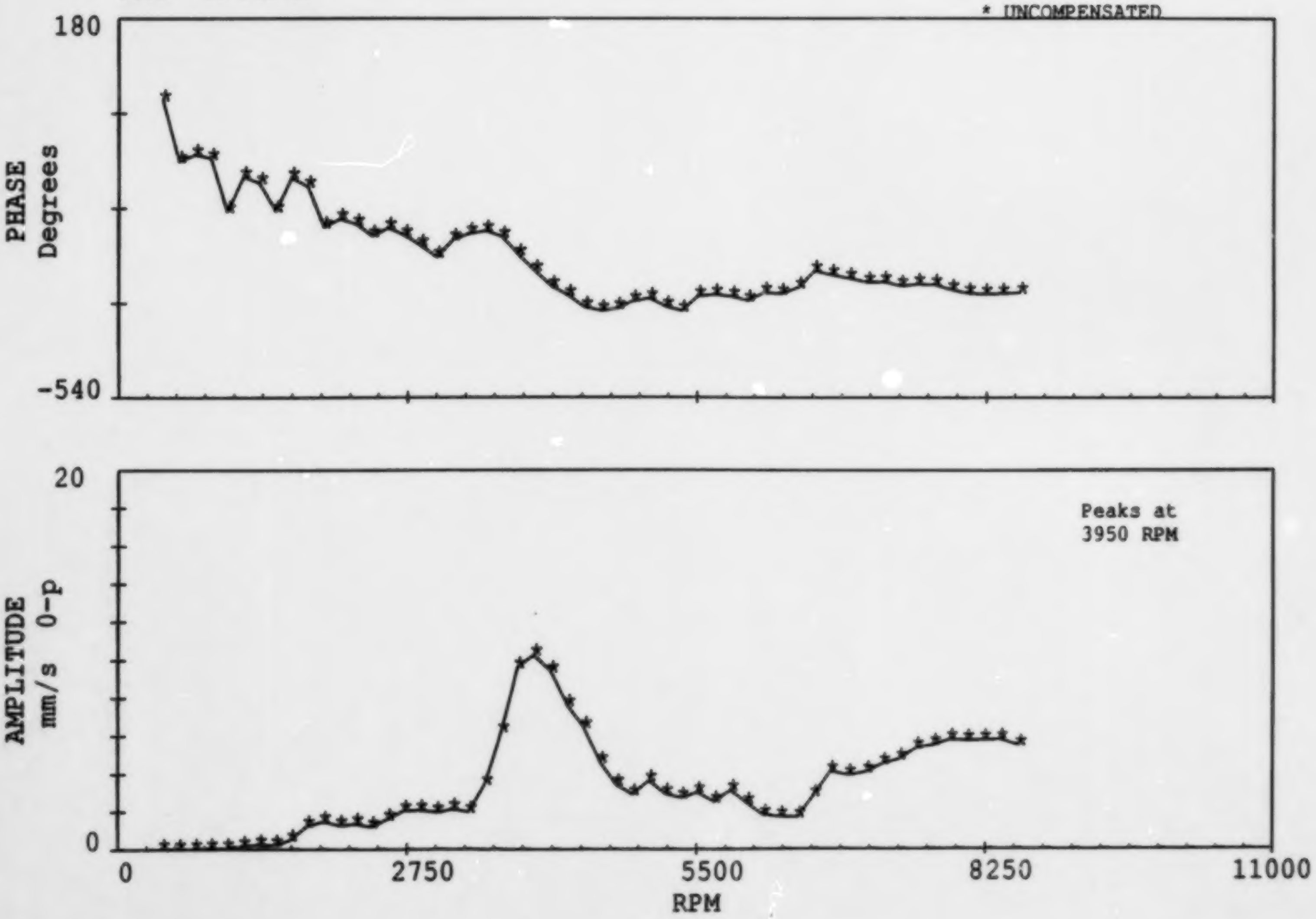


FIGURE H6

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE HOT RUNDOWN BRG #5 CASING VELOCITY AXIAL

BODE PLOT Order : 1.00
Date : 19-FEB-88

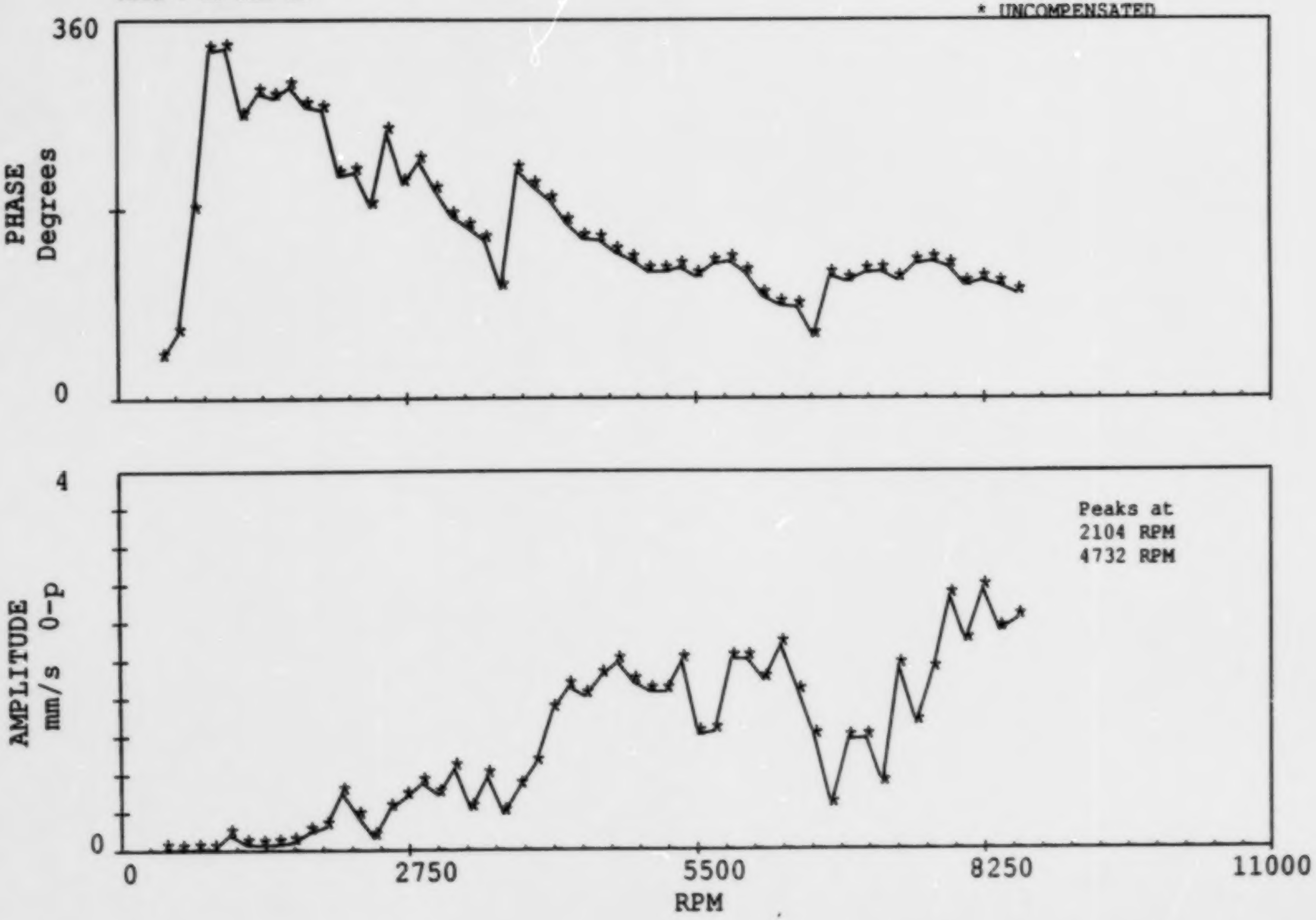


FIGURE H7

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR HOT RUNDOWN SHAFT DISPLACEMENT OB BRG VERT

BODE PLOT Order : 1.00
Date : 19-FEB-88

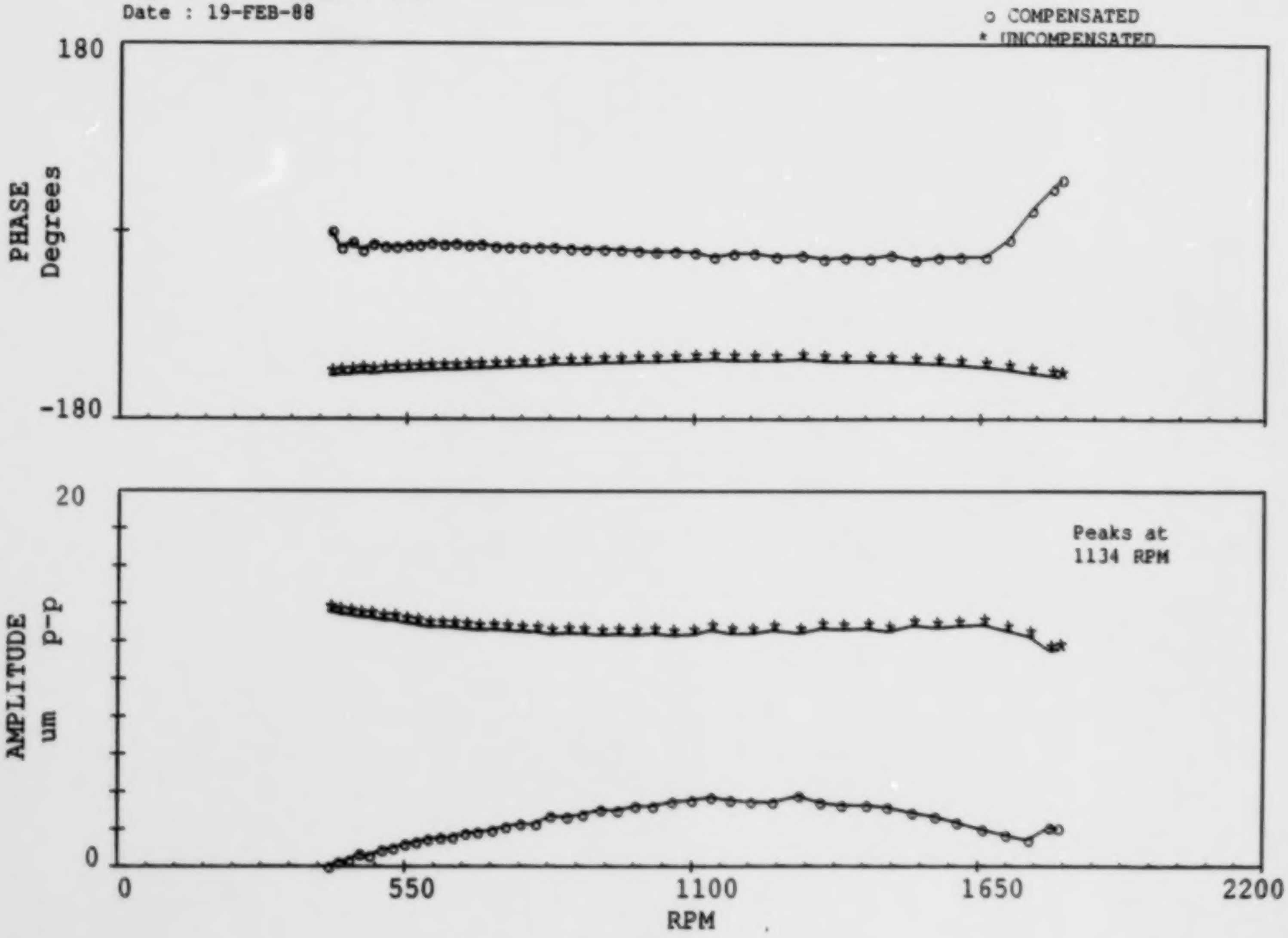


FIGURE H8

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR HOT RUNDOWN SHAFT DISPLACEMENT OB BRG HOR.

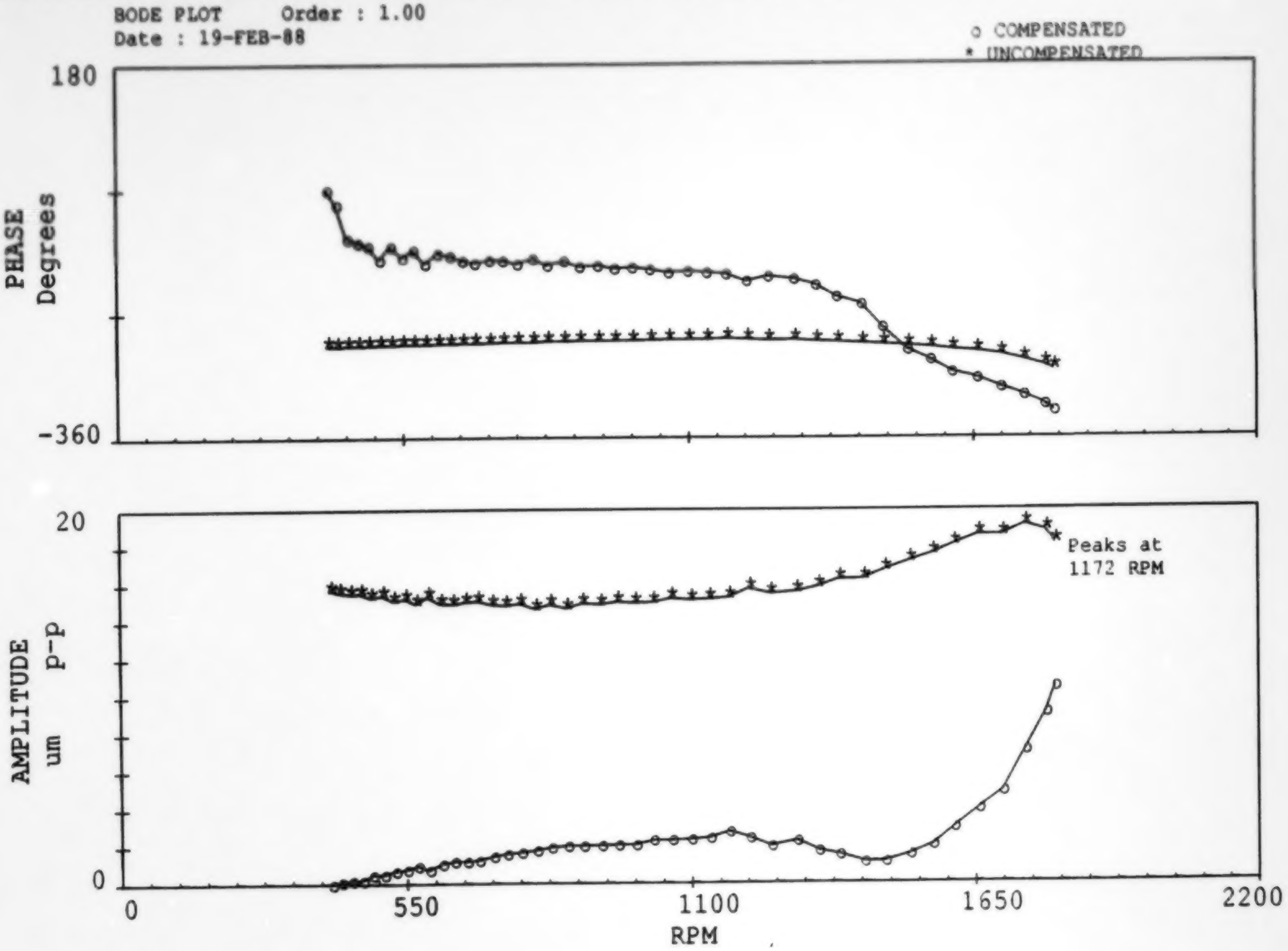


FIGURE H9

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR HOT RUNDOWN SHAFT DISPLACEMENT IB BRG VERT

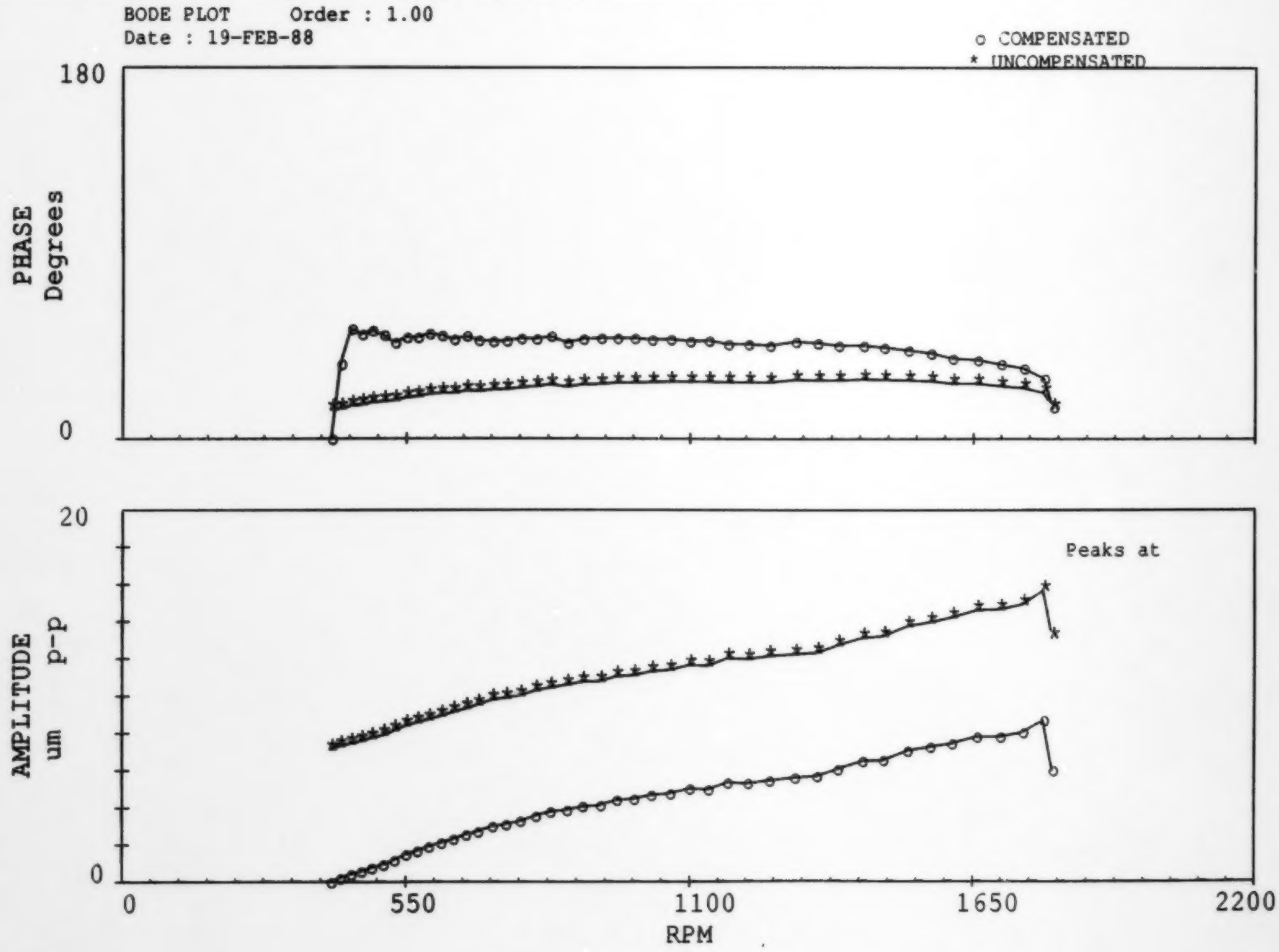


FIGURE H10

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
AC GENERATOR HOT RUNDOWN SHAFT DISPLACEMENT IB BRG HOR.

BODE PLOT Order : 1.00
Date : 19-FEB-88

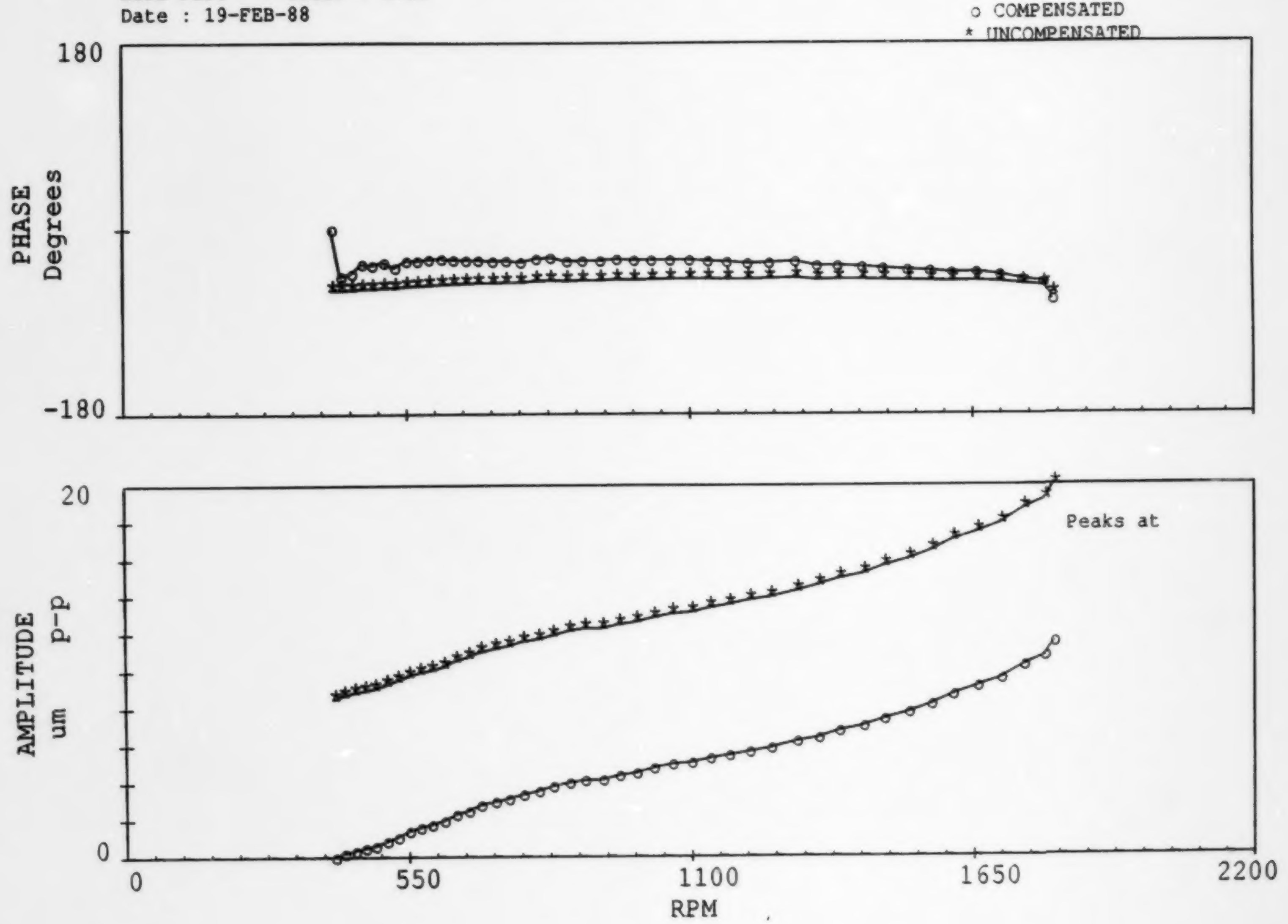
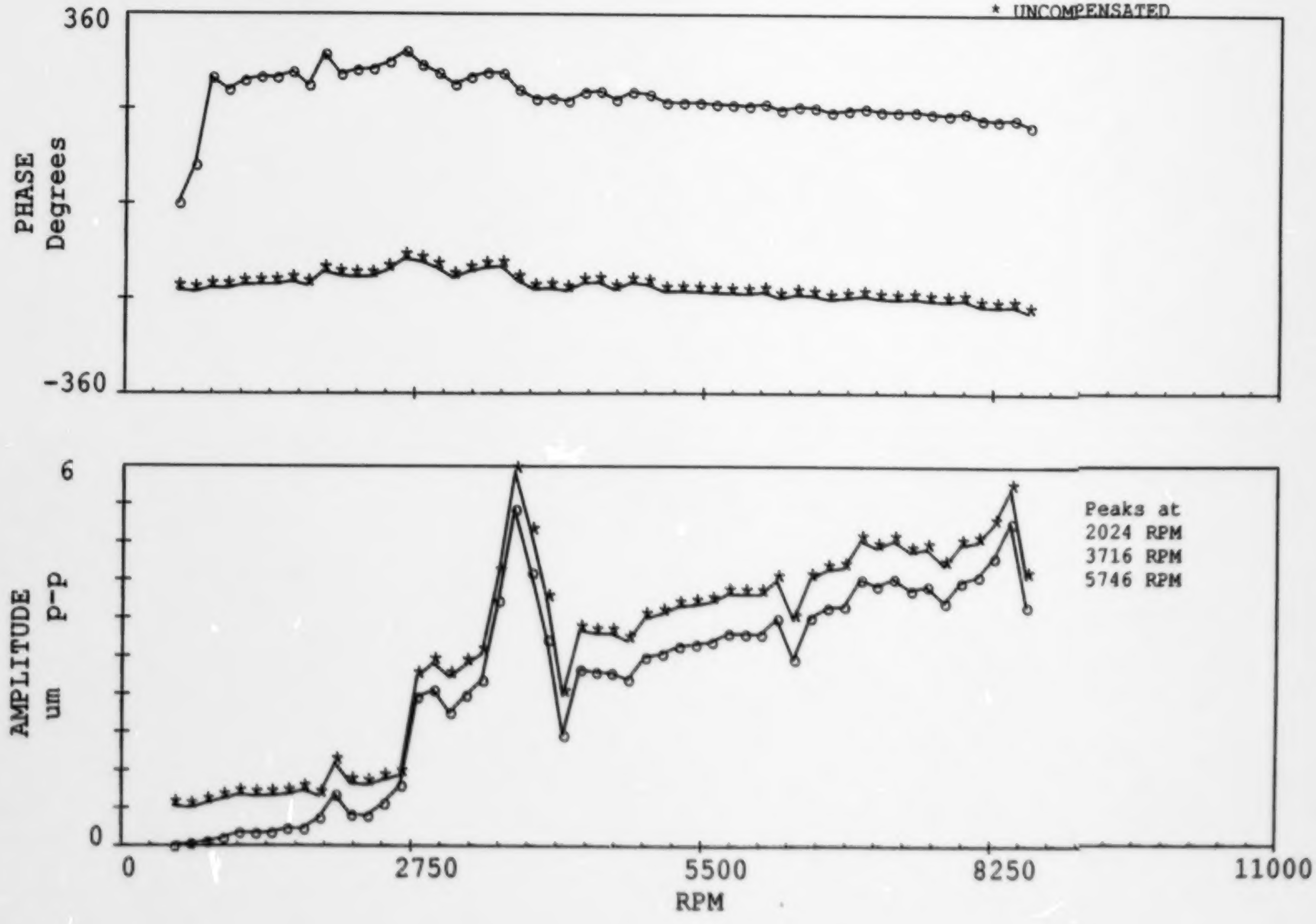


FIGURE H11


DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE HOT RUNDOWN BRG #4 SHAFT DISPLACEMENT VERT

BODE PLOT Order : 1.00
Date : 19-FEB-88

FIGURE H12

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE HOT RUNDOWN BRG #4 SHAFT DISPLACEMENT HOR.

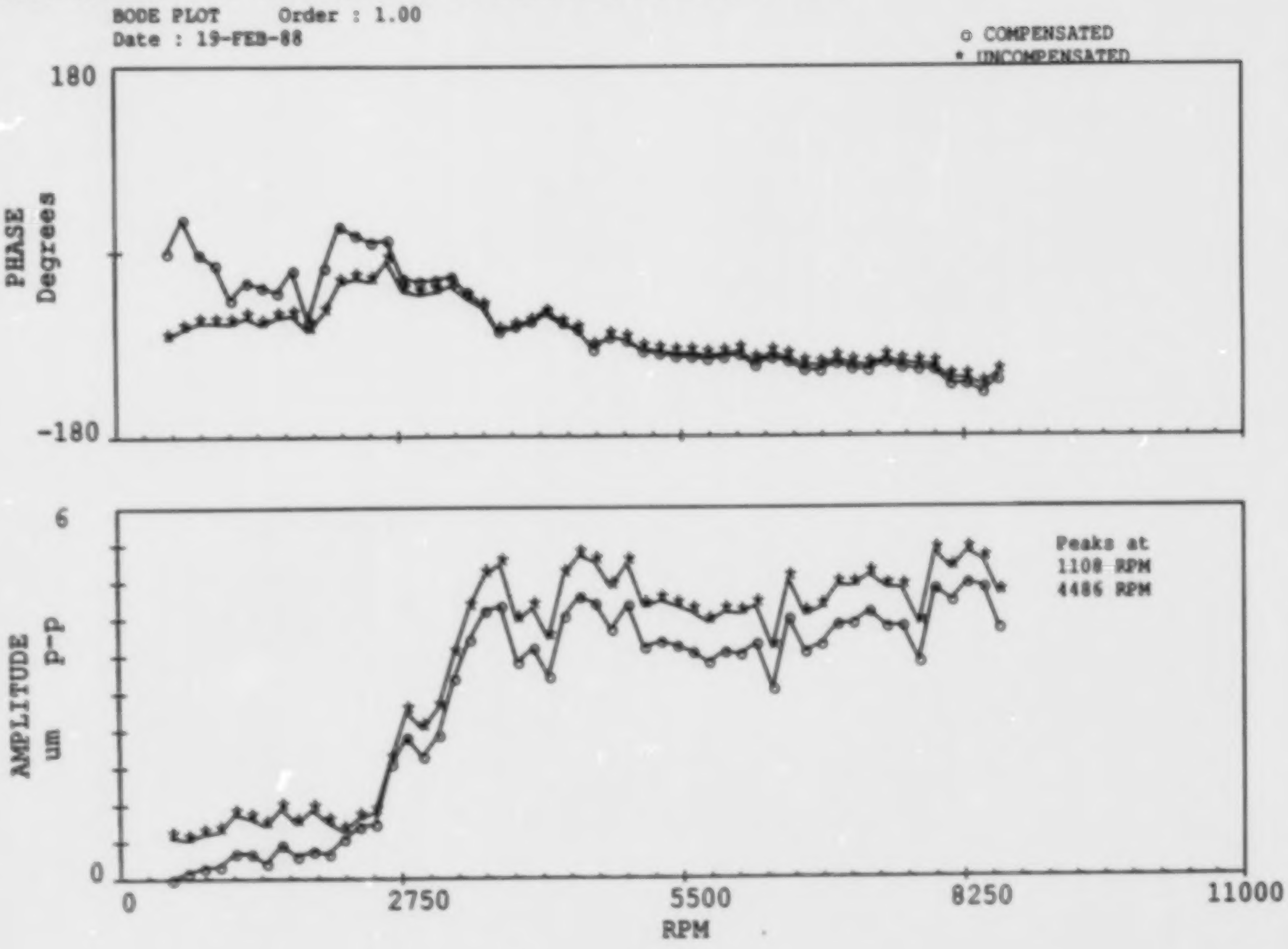


FIGURE H13

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE HOT RUNDOWN BRG #5 SHAFT DISPLACEMENT VERT

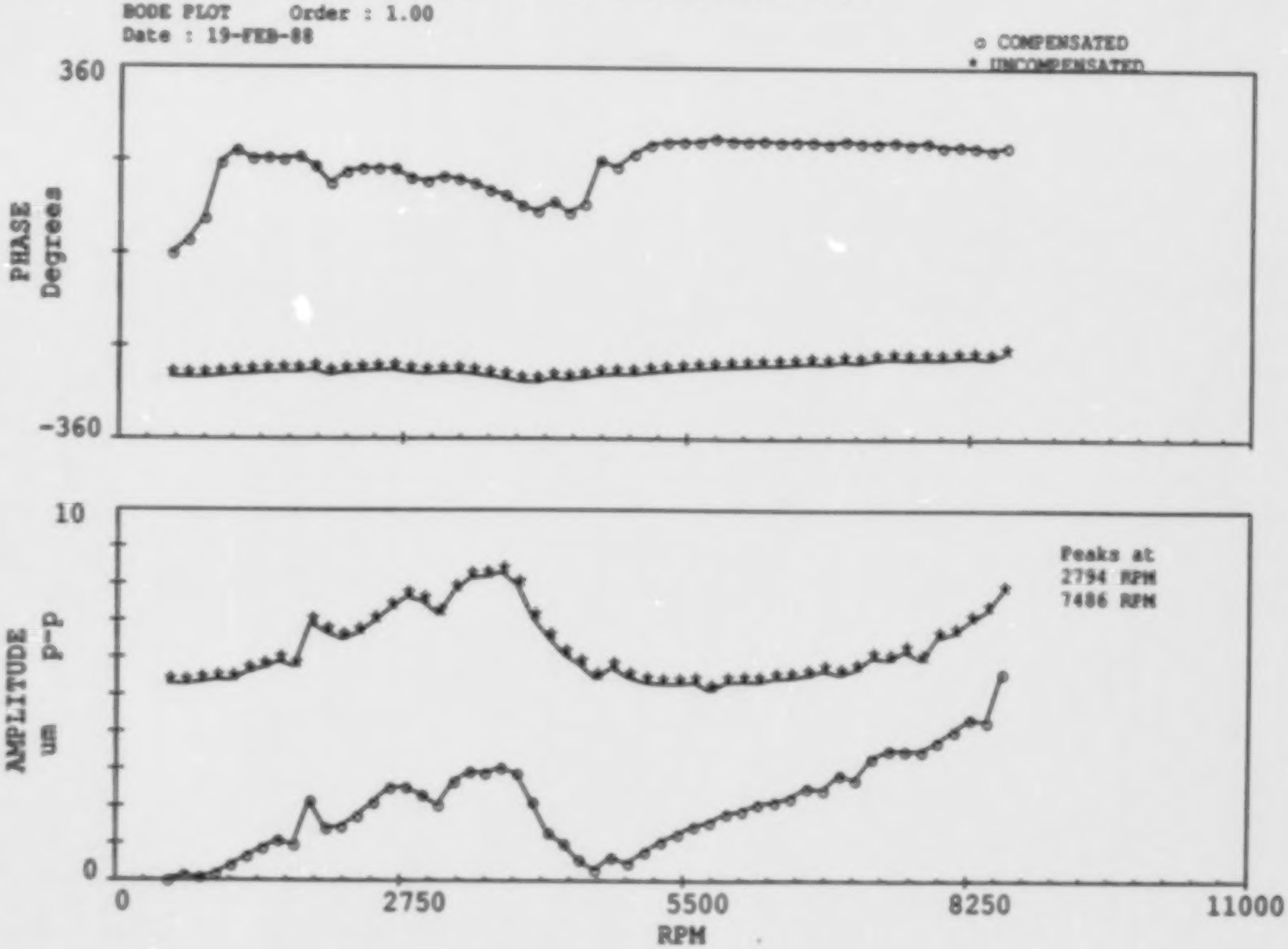


FIGURE H14

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
POWER TURBINE HOT RUNDOWN BRG #5 SHAFT DISPLACEMENT HOR.

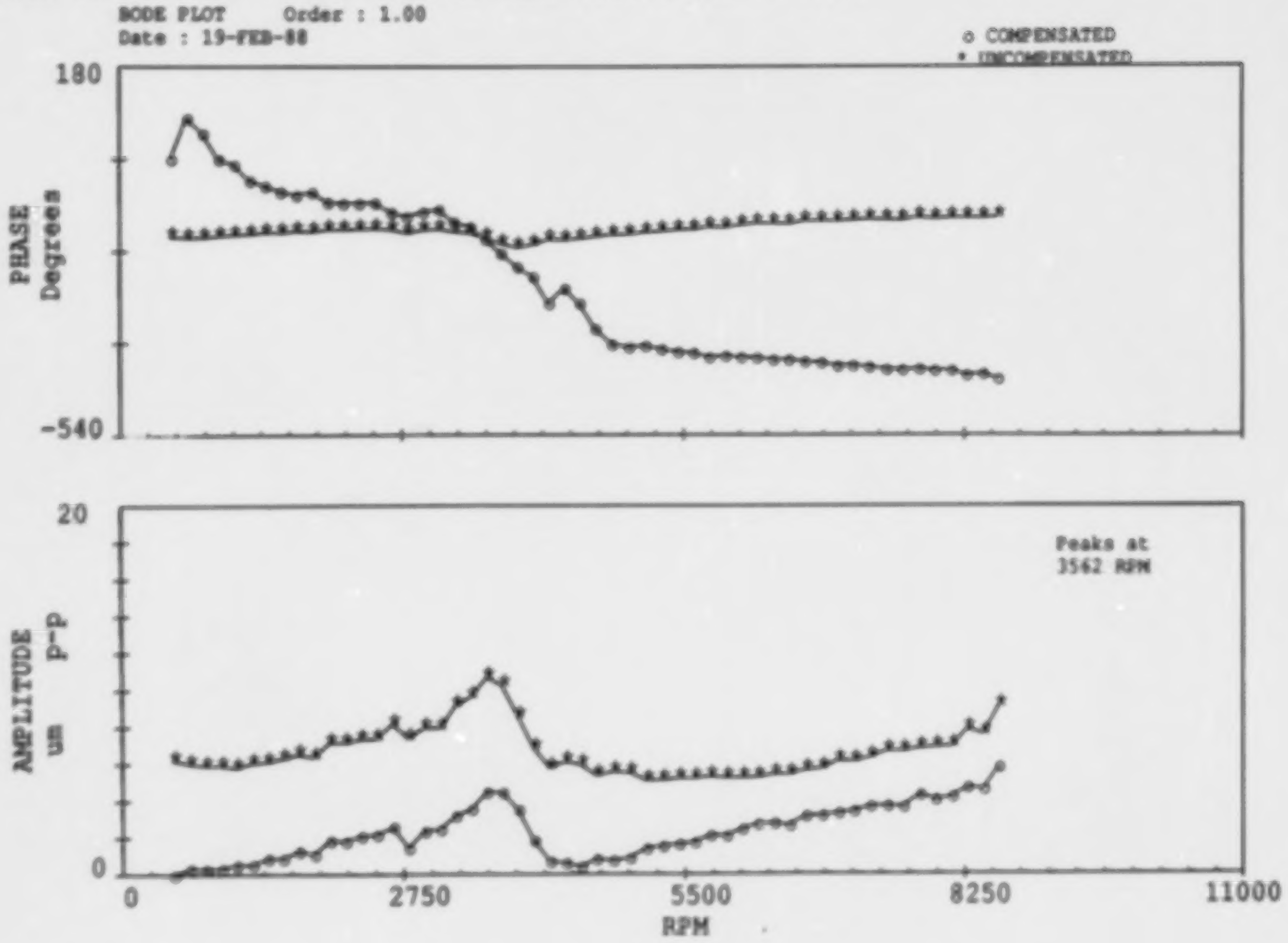


FIGURE H15

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR HOT RUNDOWN BRG #1 SHAFT DISPLACEMENT VERT

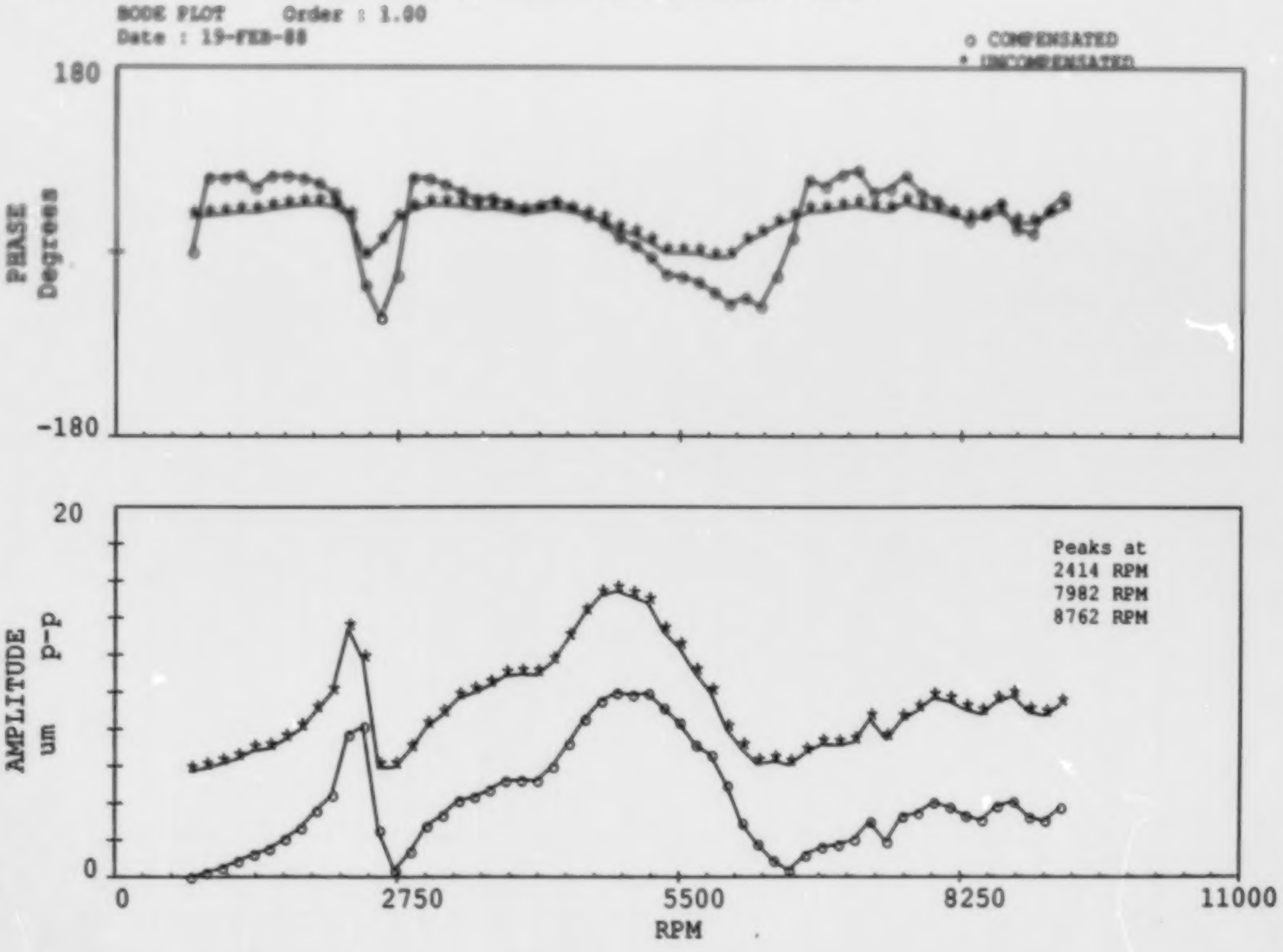


FIGURE H16

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR HOT RUNDOWN BRG #1 SHAFT DISPLACEMENT HOR.

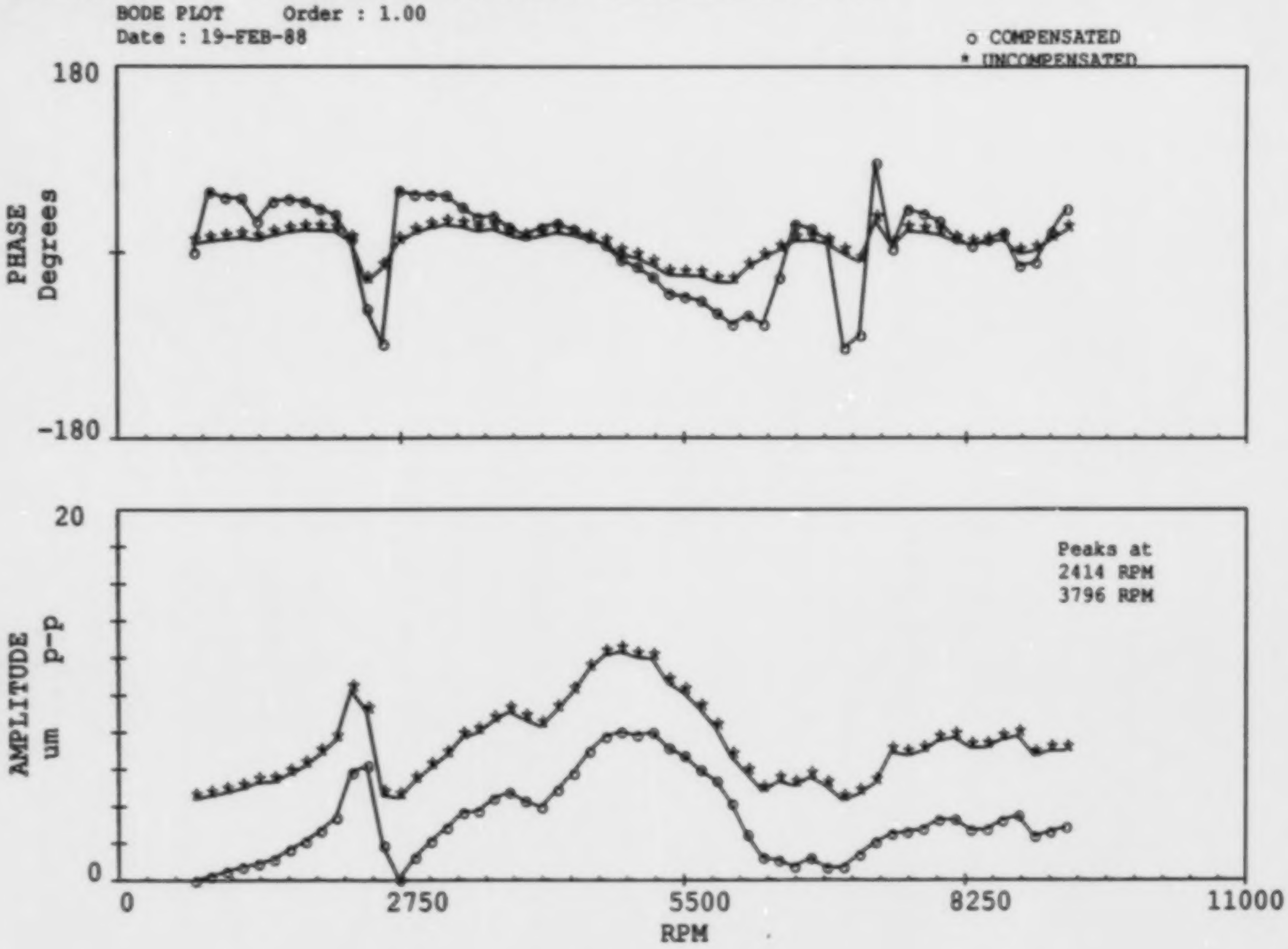


FIGURE H17

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR HOT RUNDOWN BRG #2 SHAFT DISPLACEMENT VERT

BODE PLOT Order : 1.00
Date : 19-FEB-88

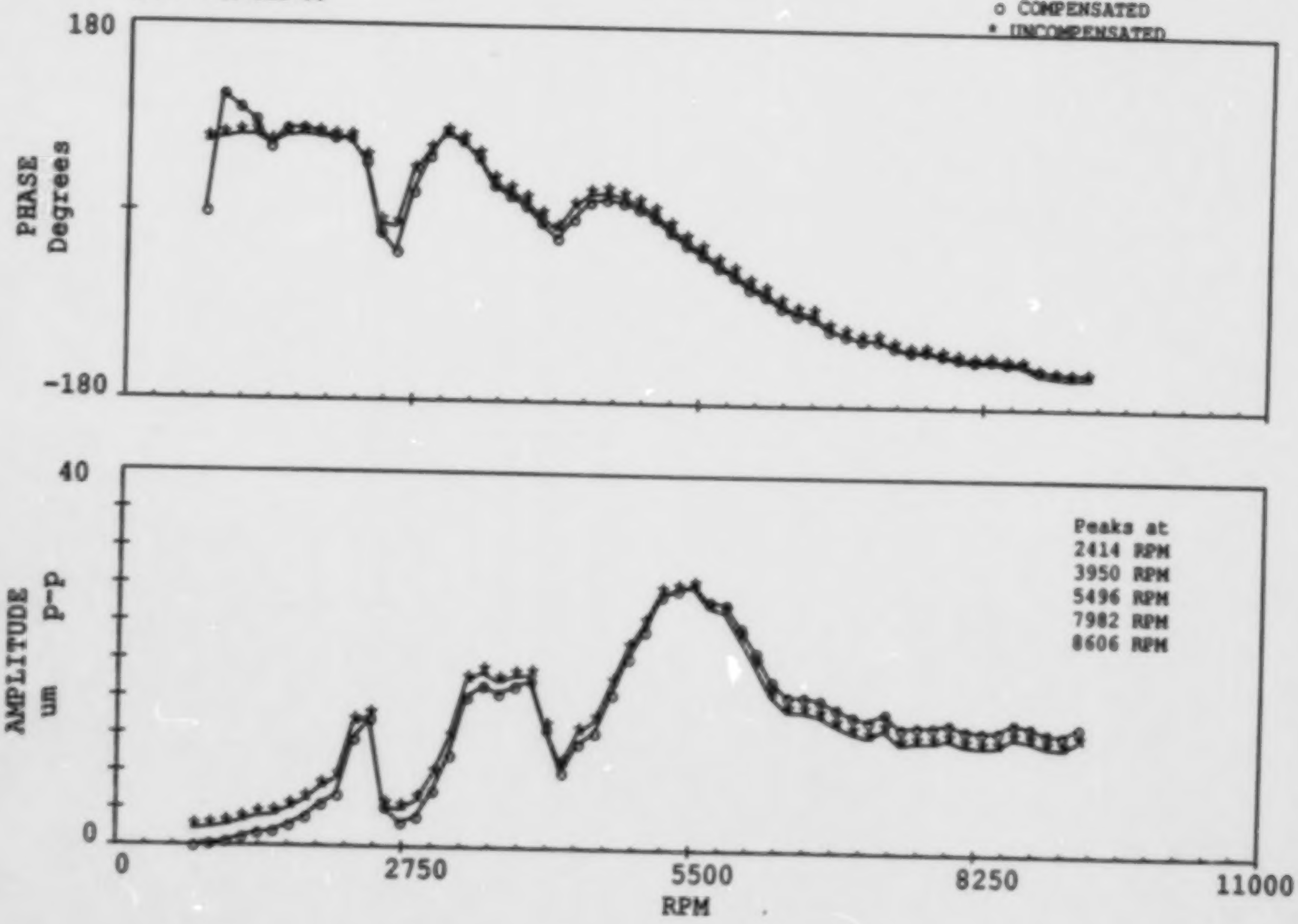


FIGURE H18

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR HOT RUNDOWN BRG #2 SHAFT DISPLACEMENT HOR.

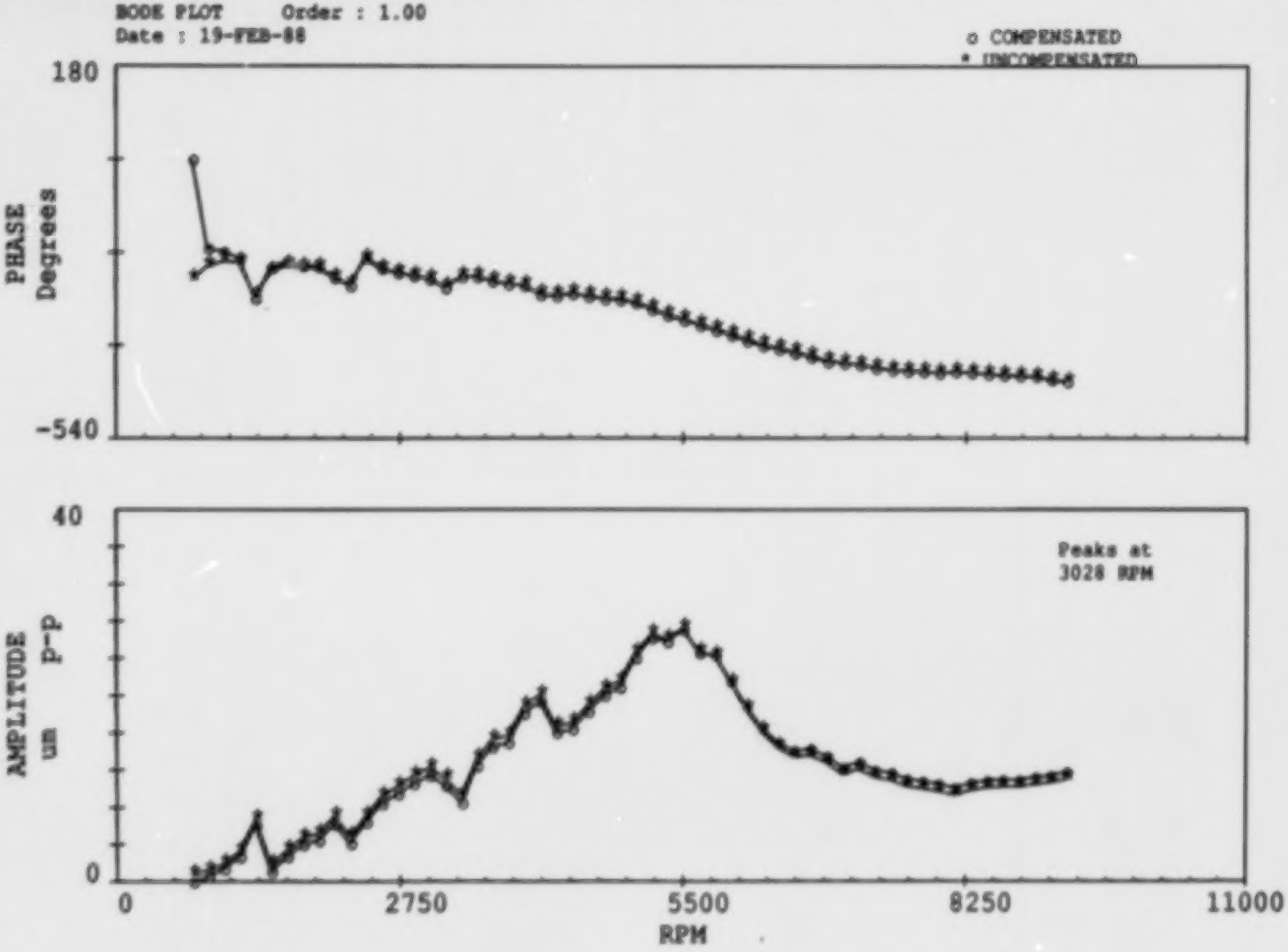


FIGURE H19

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR HOT RUNDOWN BRG #3 SHAFT DISPLACEMENT VERT

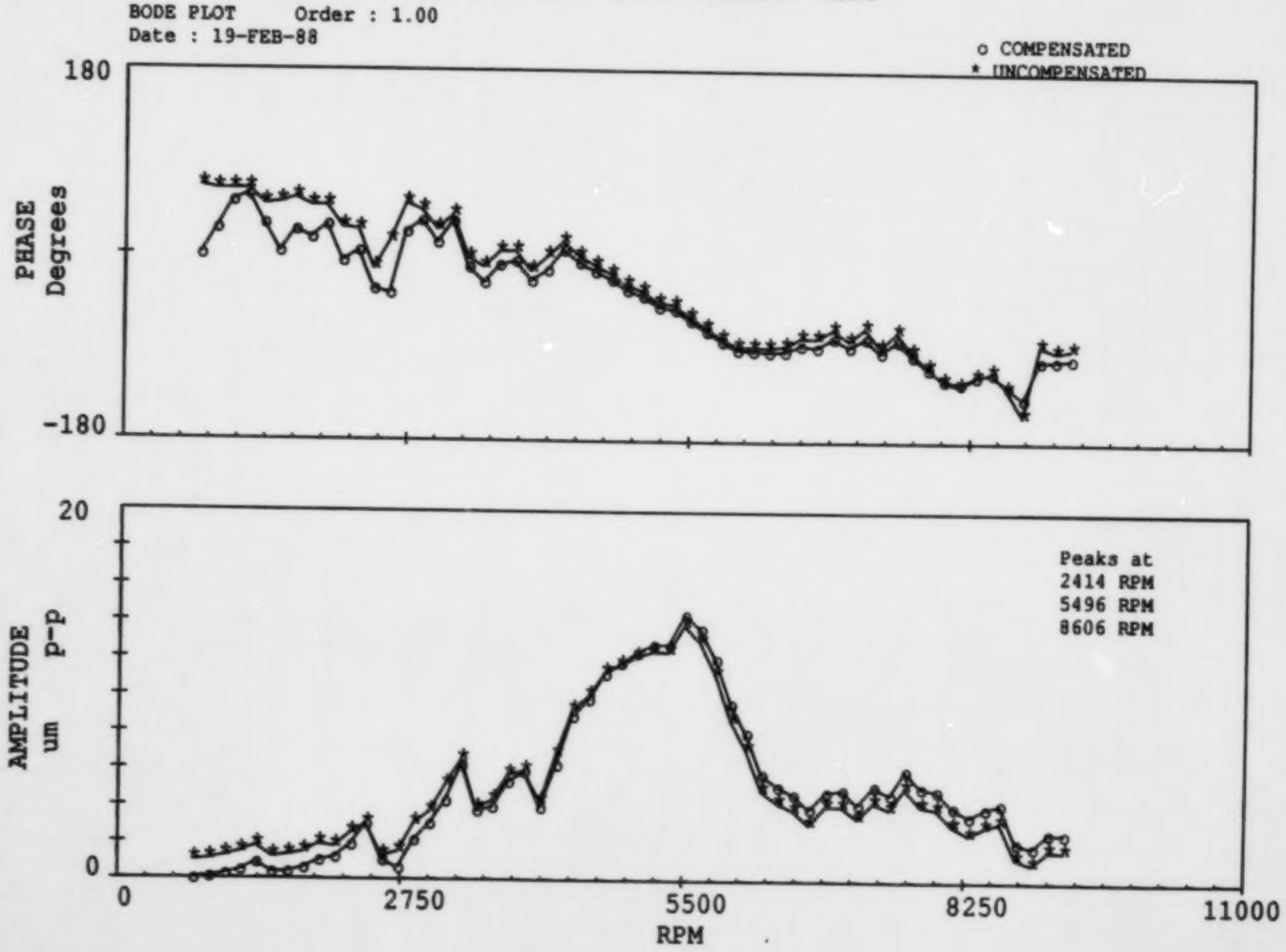


FIGURE H20

90-310

DARLINGTON NGS A EMERGENCY POWER GENERATOR #2
GAS GENERATOR HOT RUNDOWN BRG #3 SHAFT DISPLACEMENT HOR.

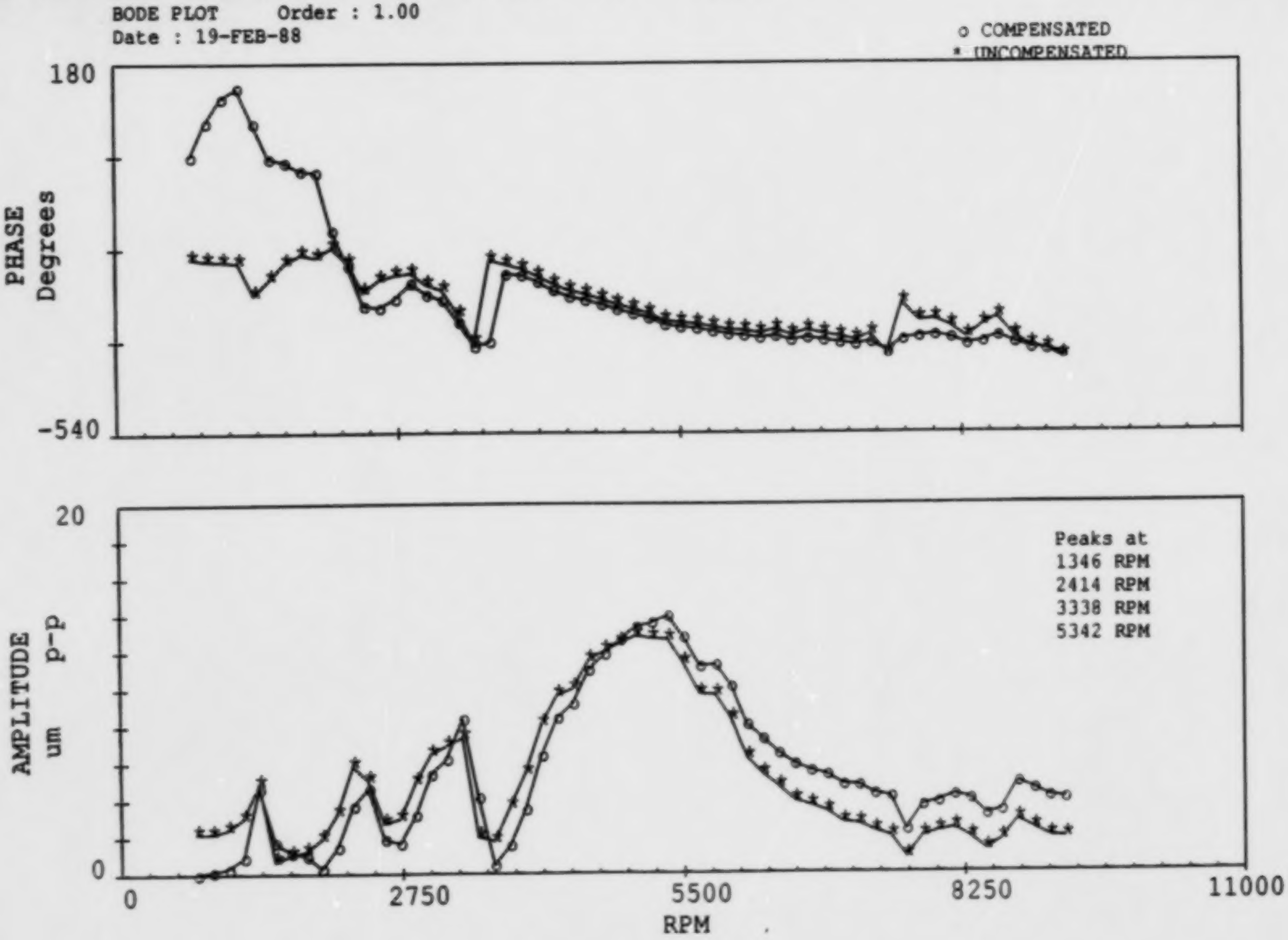


FIGURE H21

APPENDIX I

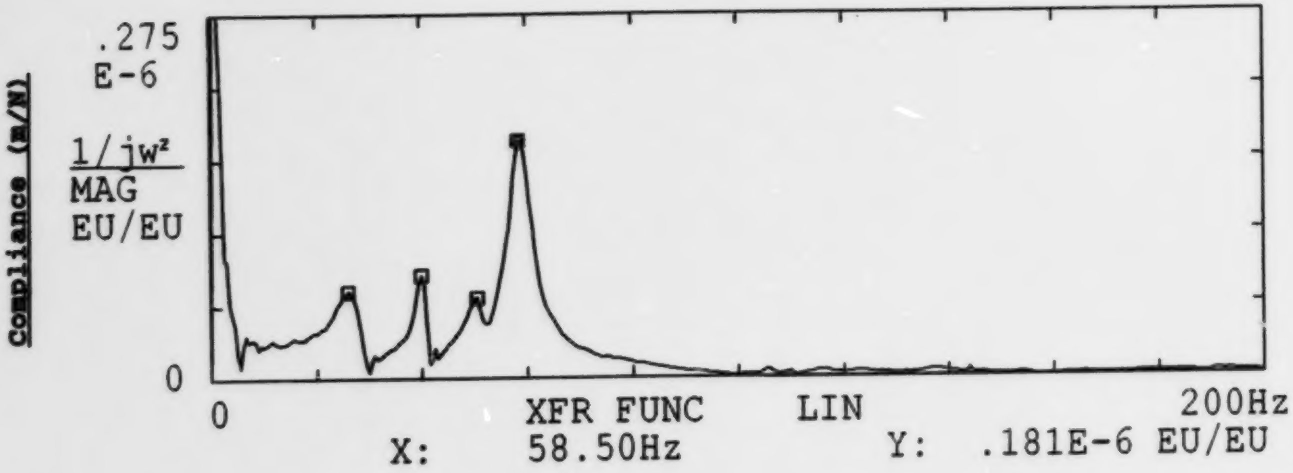
IMPACT SPECTRA

TABLE I1
DARLINGTON NGS 'A' EMERGENCY POWER GENERATOR #2
FIGURE NUMBERS OF IMPACT SPECTRA

Measurement Location		Impact Spectrum Figure No
Exciter	- Vertical Direction	I1
	- Horizontal Direction	I2
AC Generator Outboard Bearing Casing	- Vertical Direction	I3
	- Horizontal Direction	I4
	- Axial Direction	I5
AC Generator Inboard Bearing Casing	- Vertical Direction	I6
	- Horizontal Direction	I7
	- Axial Direction	I8
AC Generator Frame (Near Base)	- Horizontal Direction	I9
Reduction Gearbox	- Vertical Direction	I10
	- Horizontal Direction	I11
Power Turbine Bearing No 5 Casing	- Vertical Direction	I12
	- Horizontal Direction	I13
Gas Producer (Near Bearing No 2) Casing	- Vertical Direction	I14
	- Horizontal Direction	I15

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
EXCITER VERTICAL DIRECTION

```
                   XFER FUNC  MAG - PH
1      26.00Hz          .669E-7 EU/EU   -43.8 deg
2      40.00            .786E-7         -47.3
3      50.50            .617E-7         -43.1
4      58.50            .181E-6         -85.4
5
6
7
8
9
10
```

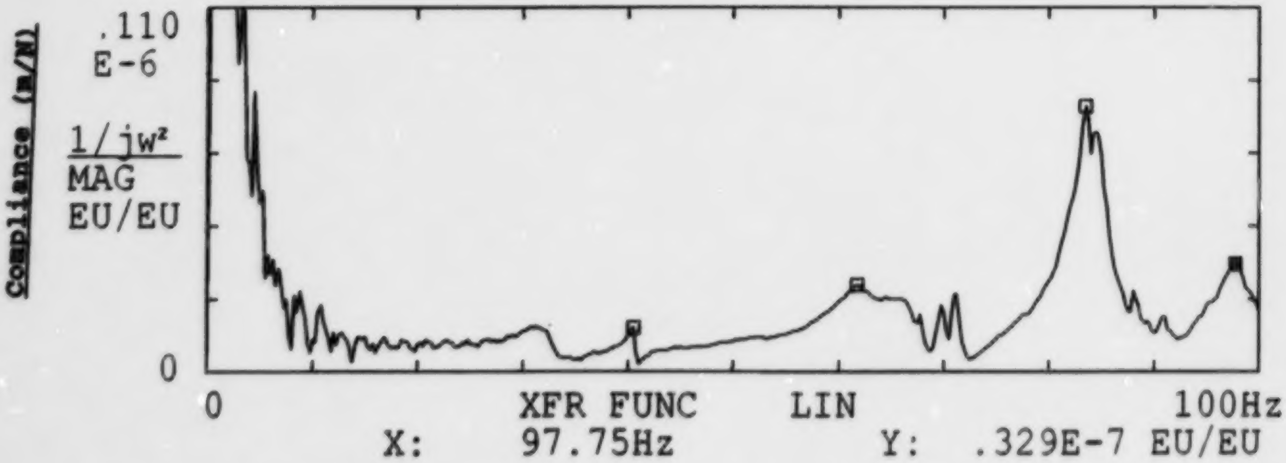


00:45

FIGURE I1

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
EXCITER HORIZONTAL DIRECTION

		XFER FUNC MAG - PH	
1	40.50Hz	.136E-7 EU/EU	122.4 deg
2	61.75	.263E-7	149.1
3	83.50	.804E-7	106.7
4	97.75	.329E-7	53.1
5			
6			
7			
8			
9			
10			

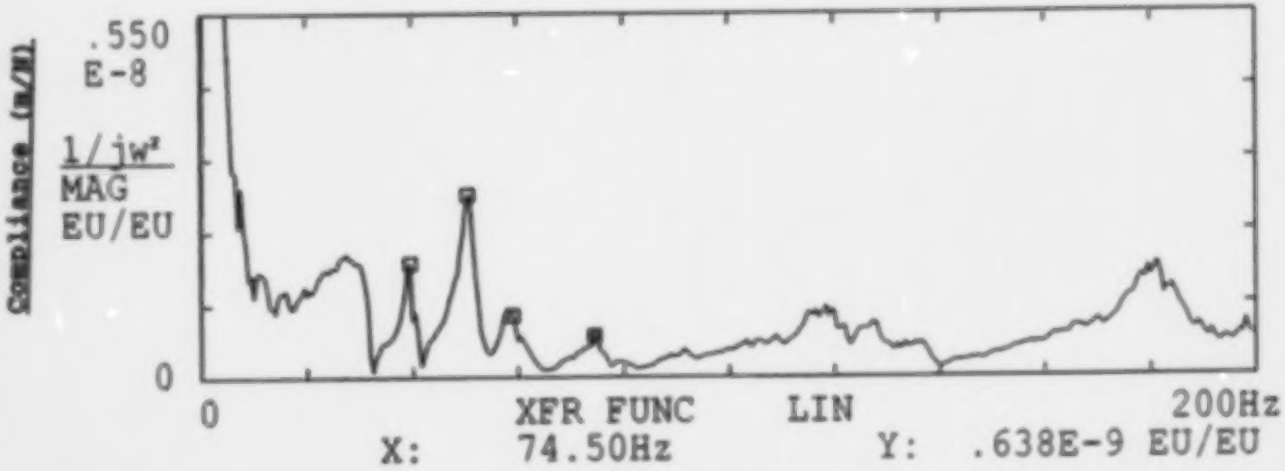


00:42

FIGURE I2

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
AC GENERATOR OUTBOARD BEARING CASING VERTICAL DIRECTION

	XFER FUNC	MAG - PH	
1	39.50Hz	.176E-8 EU/EU	-71.6 deg
2	50.50	.279E-8	-69.0
3	59.00	.955E-9	-98.1
4	74.50	.638E-9	-55.3
5			
6			
7			
8			
9			
10			

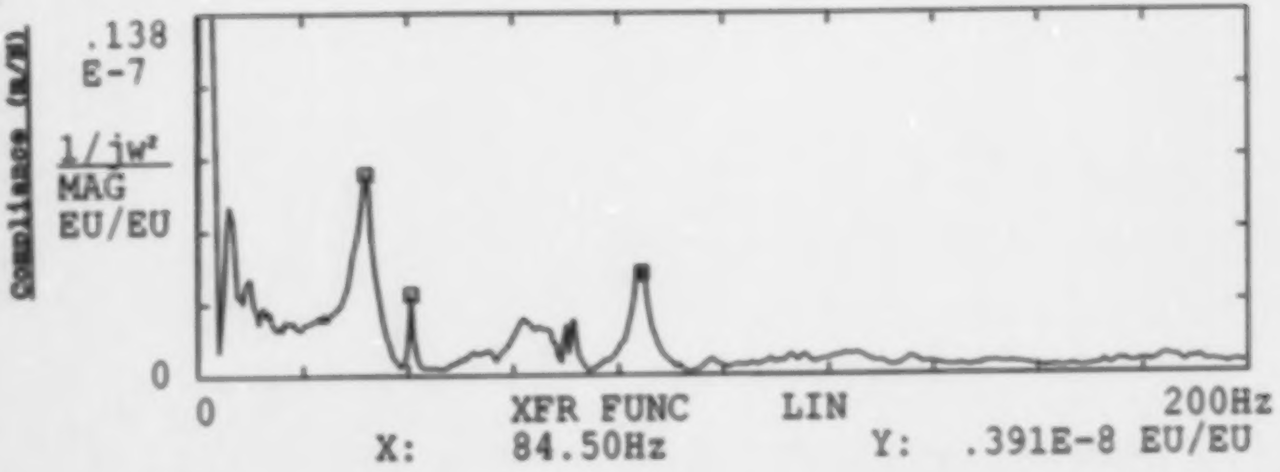


00:33

FIGURE I3

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
AC GENERATOR OUTBOARD BEARING CASING HORIZONTAL DIRECTION

```
                 XFER FUNC  MAG - PH
 1      32.00Hz        .769E-8 EU/EU   105.5 deg
 2      40.50          .314E-8          92.1
 3      84.50          .391E-8          84.8
 4
 5
 6
 7
 8
 9
10
```

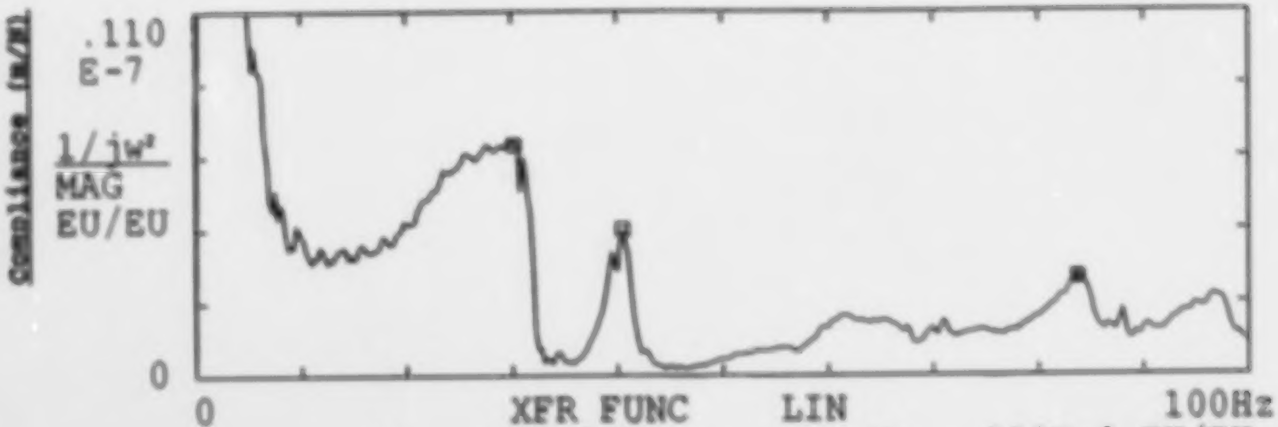


00:35

FIGURE I4

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM AC GENERATOR OUTBOARD BEARING CASING AXIAL DIRECTION

```
               XFER FUNC  MAG - PH
 1      30.25Hz        .701E-8 EU/EU  -115.0 deg
 2      40.50          .449E-8          -91.9
 3      83.75          .298E-8          -37.4
 4
 5
 6
 7
 8
 9
10
```



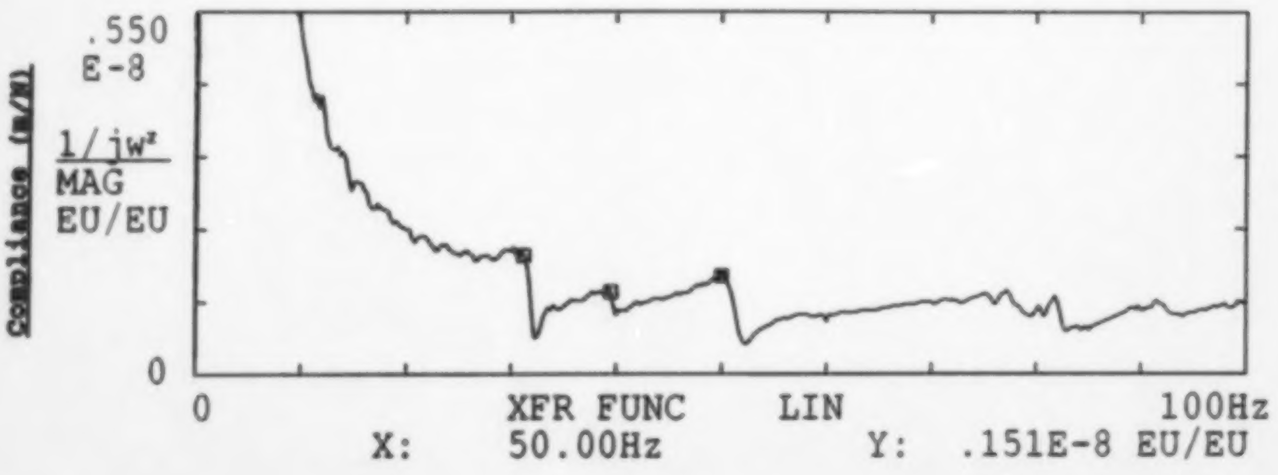
```
X:    83.75Hz                Y:  .298E-8 EU/EU
```

00:55

FIGURE I5

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
AC GENERATOR INBOARD BEARING CASING VERTICAL DIRECTION

```
                XFER FUNC  MAG - PH
  1    31.25Hz          .182E-8 EU/EU   -27.2 deg
  2    39.50            .127E-8          -11.7
  3    50.00            .151E-8          -20.4
  4
  5
  6
  7
  8
  9
 10
```

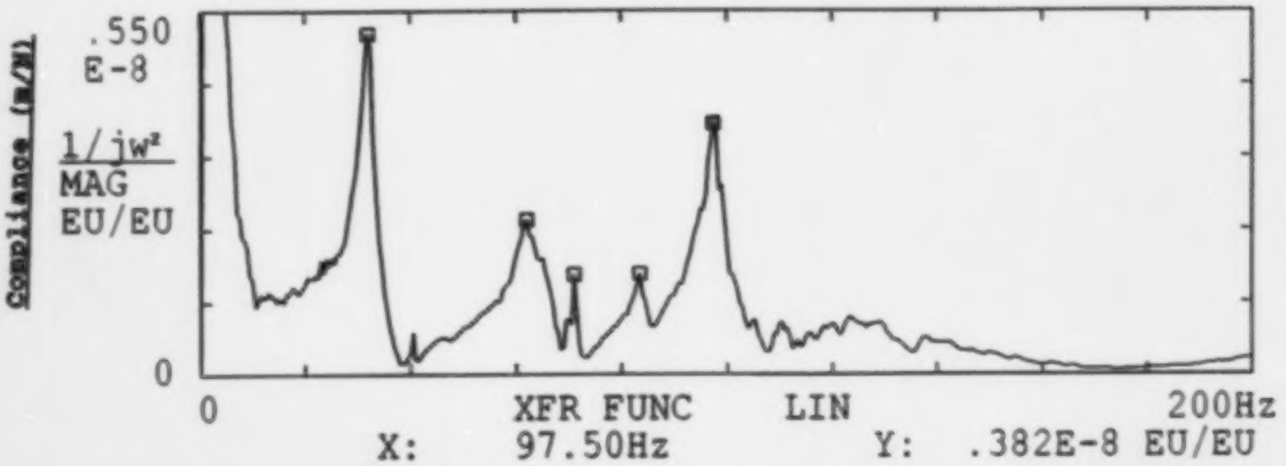


01:14

FIGURE I6

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
AC GENERATOR INBOARD BEARING CASING HORIZONTAL DIRECTION

```
                XFER FUNC  MAG - PH
 1     32.00Hz        .518E-8 EU/EU   108.6 deg
 2     62.00          .236E-8         132.6
 3     71.00          .152E-8         112.3
 4     83.50          .155E-8         137.6
 5     97.50          .382E-8          92.6
 6
 7
 8
 9
10
```

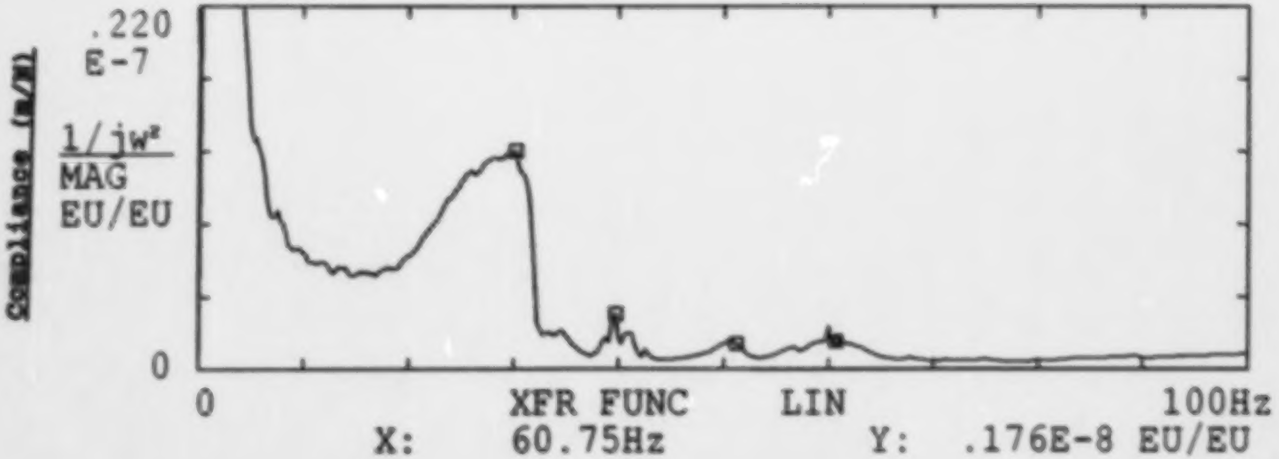


01:11

FIGURE I7

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
AC GENERATOR INBOARD BEARING CASING AXIAL DIRECTION

```
              XFER FUNC  MAG - PH
 1     30.25Hz       .133E-7 EU/EU  -119.9 deg
 2     39.75         .343E-8        -110.1
 3     51.25         .161E-8         -85.3
 4     60.75         .176E-8         -72.9
 5
 6
 7
 8
 9
10
```



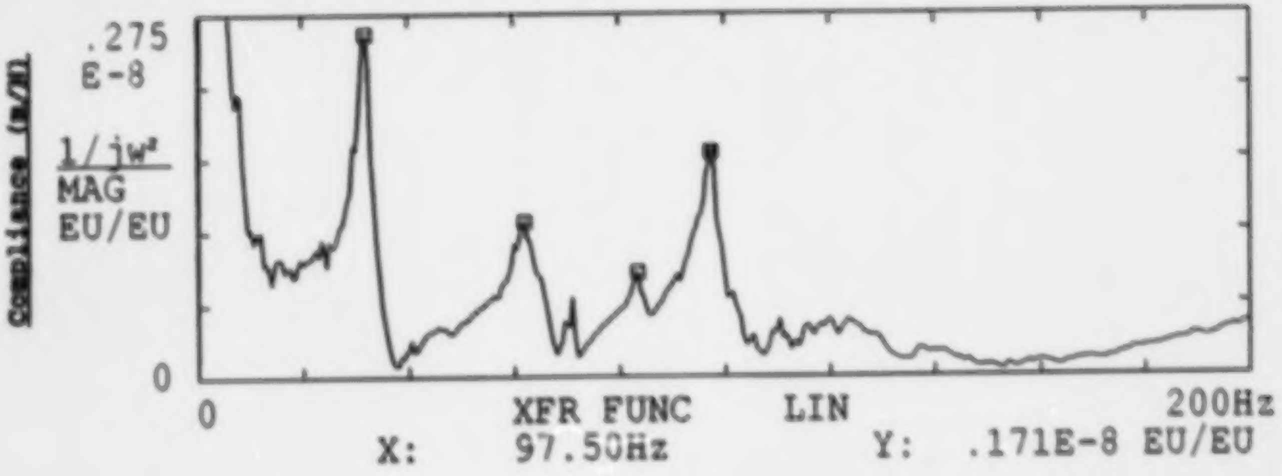
01:16

FIGURE I8

DMGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
AC GENERATOR FRAME (NEAR BASE) HORIZONTAL DIRECTION

		XFER FUNC	MAG - PH
1	32.00Hz	.262E-8 EU/EU	-73.2 deg
2	62.00	.119E-8	-47.6
3	83.50	.800E-9	-34.5
4	97.50	.171E-8	-87.1
5			
6			
7			
8			
9			
10			

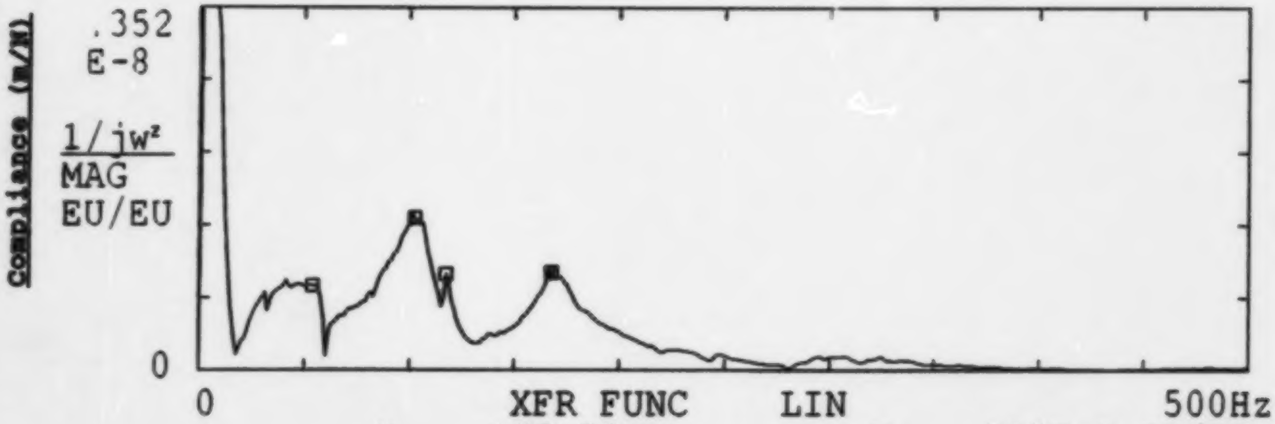
FIGURE I9



01:05

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM REDUCTION GEARBOX VERTICAL DIRECTION

```
               XFER FUNC  MAG - PH
 1   53.75Hz       .829E-9 EU/EU   -41.4 deg
 2  102.50         .149E-8         -68.1
 3  117.50         .943E-9         -96.2
 4  167.50         .950E-9         -90.5
 5
 6
 7
 8
 9
10
```



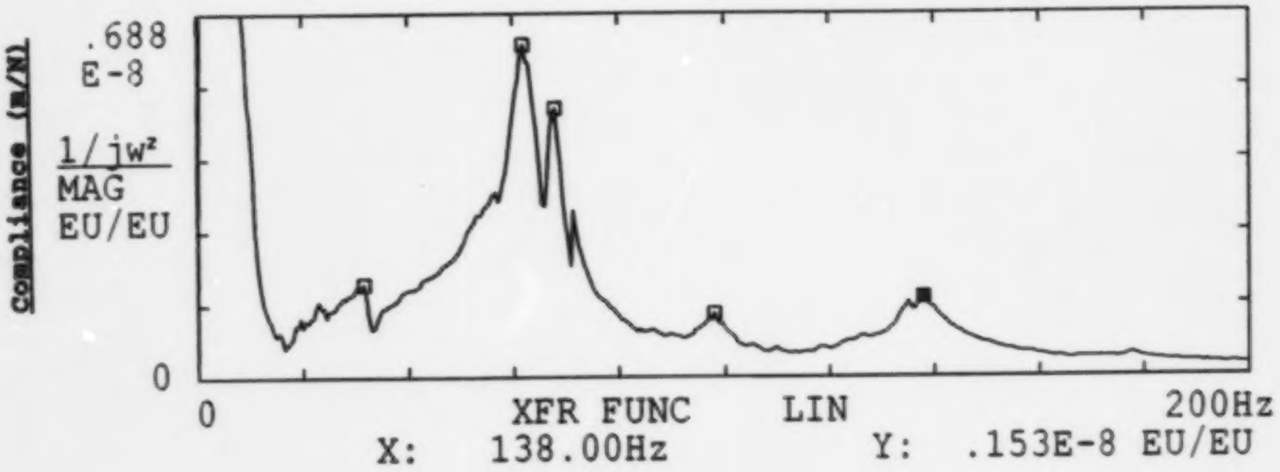
```
X:  167.50Hz          Y:  .950E-9 EU/EU
```

01:39

FIGURE I10

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
REDUCTION GEARBOX HORIZONTAL DIRECTION

		XFER FUNC	MAG - PH
1	31.50Hz	.178E-8 EU/EU	-20.4 deg
2	62.00	.631E-8	-60.1
3	68.00	.511E-8	-98.3
4	98.00	.121E-8	-110.1
5	138.00	.153E-8	-117.7
6			
7			
8			
9			
10			

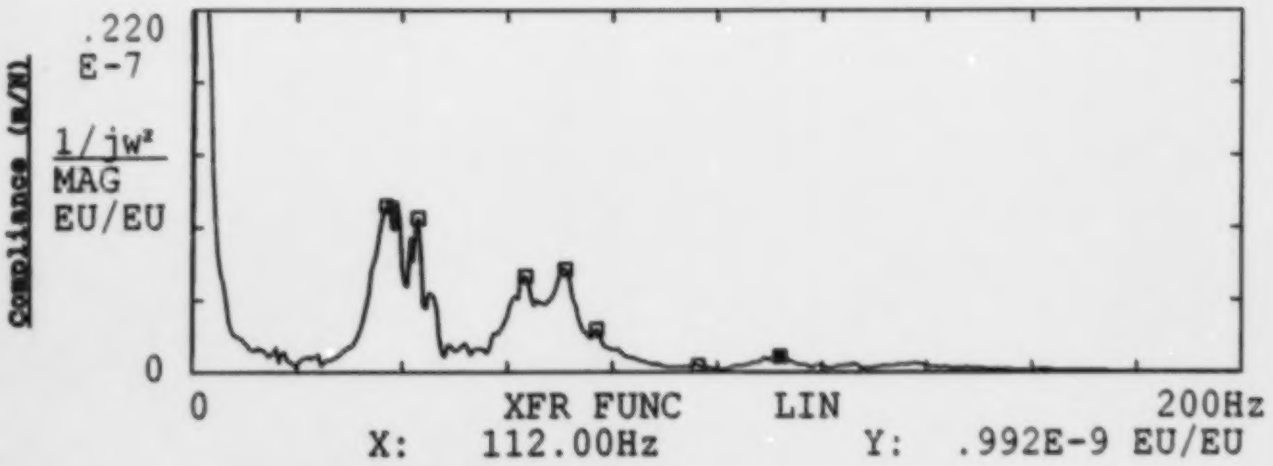


01:17

FIGURE I11

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
POWER TURBINE BEARING NO 5 CASING VERTICAL DIRECTION

```
                    XFER FUNC  MAG - PH
 1      37.00Hz         .102E-7 EU/EU    98.1 deg
 2      43.00           .941E-8         -12.6
 3      63.50           .588E-8        -130.4
 4      71.00           .631E-8         126.6
 5      77.00           .267E-8          60.9
 6      96.50           .459E-9          16.4
 7     112.00           .992E-9           -.6
 8
 9
10
```

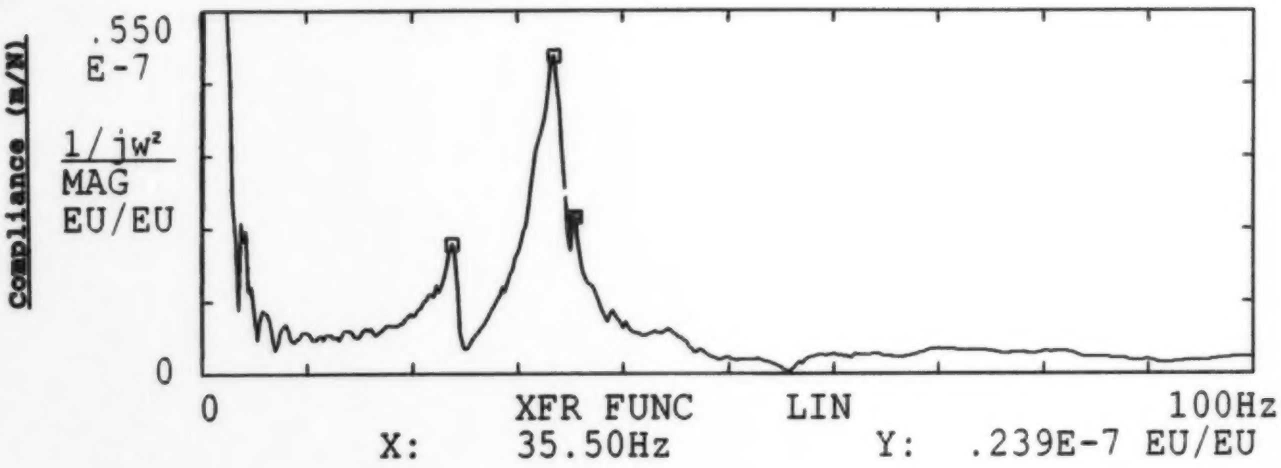


01:30

FIGURE I12

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
POWER TURBINE BEARING NO 5 CASING HORIZONTAL DIRECTION

		XFER FUNC	MAG - PH
1	23.75Hz	.197E-7 EU/EU	-58.8 deg
2	33.50	.484E-7	-112.1
3	35.50	.239E-7	-153.9
4			
5			
6			
7			
8			
9			
10			

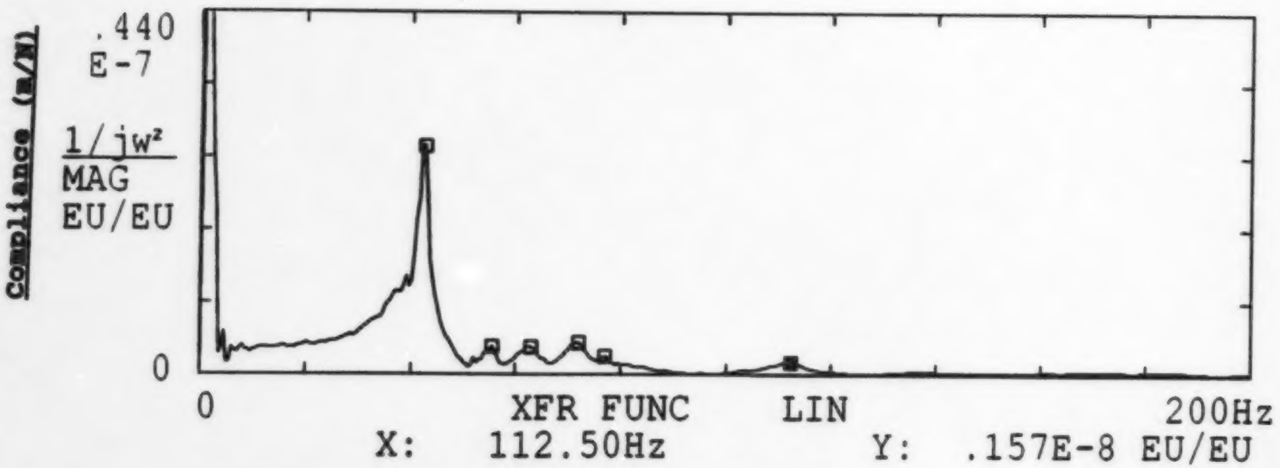


01:18

FIGURE I13

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
GAS PRODUCER (NEAR BEARING NO 2) CASING VERTICAL DIRECTION

```
                 XFER FUNC  MAG - PH
  1      42.50Hz        .278E-7 EU/EU    -96.0 deg
  2      55.50          .356E-8         -100.0
  3      63.00          .332E-8          -95.2
  4      72.00          .399E-8         -115.7
  5      77.00          .228E-8         -133.0
  6     112.50          .157E-8          -91.0
  7
  8
  9
 10
```

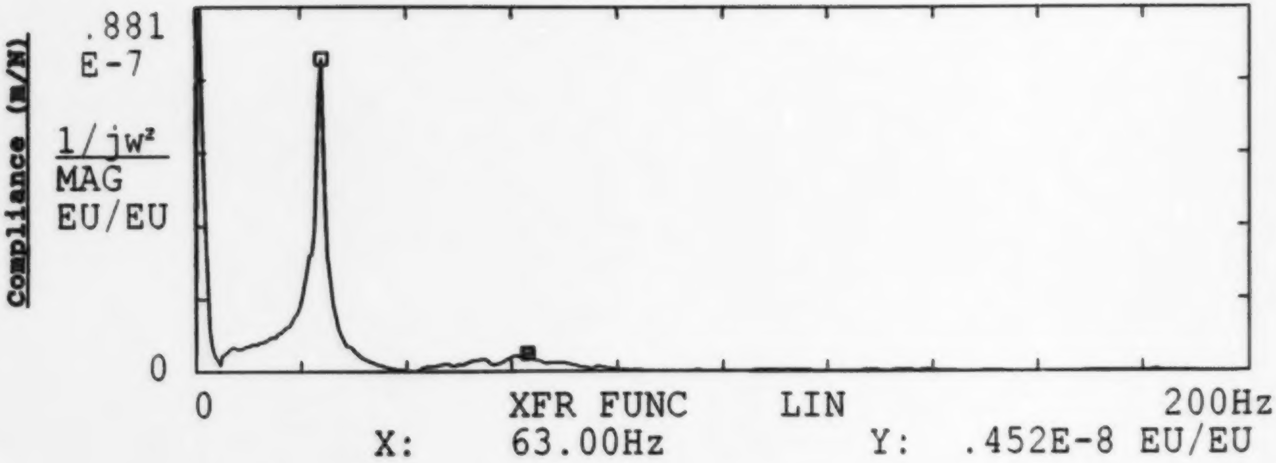


01:27

FIGURE I14

DNGS 'A' EMERGENCY POWER GENERATOR #2 - IMPACT SPECTRUM
GAS PRODUCER (NEAR BEARING NO 2) CASING HORIZONTAL DIRECTION

```
               XFER FUNC  MAG - PH
 1    24.00Hz        .762E-7 EU/EU  -109.1 deg
 2    63.00          .452E-8         -99.8
 3
 4
 5
 6
 7
 8
 9
10
```



01:23

FIGURE I15

APPENDIX J

INSTRUMENTATION AND MEASUREMENTS

1.0 INSTRUMENTATION

The main components of the instrumentation used in obtaining the various measurements are listed in Table 1 and are further discussed below.

On-line Vibration Monitoring System

Each turbine-generator unit has an on-line vibration monitoring system which measures the overall vibration levels at selected locations. Velocity transducers are mounted in a vertical direction on the inboard and outboard bearing casings of the AC generator, on the reduction gear box (RGB) casing and on the accessory gear box casing. In addition, at each of the bearings No 1 through No 5, two displacement transducers are mounted radially at 90 degrees to each other (horizontal and vertical directions).

Transducers used for Vibration Acceptance Tests

The permanently installed shaft displacement transducers at bearings No 1 through No 5 were utilized for the vibration acceptance tests. In addition, two displacement transducers were installed in the vertical and horizontal directions at each end of the AC generator close to the bearings. The sensitivity of the AC generator, power turbine and gas producer displacement transducers is 7.87 millivolts/micrometer (200 mv/mil).

The AC generator inboard and outboard bearing casing velocities, the reduction and accessory gear box casing velocities, and the power turbine casing (close to Bearing No 5) velocities were measured using accelerometers. Velocity measurements were generally obtained in the vertical, horizontal, and axial directions.

A photoelectric tachometer probe (Bruel & Kjaer MM 0024) was installed at the inboard end of the generator to provide a reference mark for phase angle and shaft speed measurements. Speed measurements on the power turbine and gas producer were obtained using the permanently installed speed transducers.

2.0 MEASUREMENTS

Overall Vibration Levels

The overall casing velocity levels were determined from accelerometer signals which were integrated to velocity and then analyzed with a Bently Nevada Digital Vector Filter (DVF 3). True peak and RMS overall velocity levels were measured.

Shaft overall displacement levels were obtained by analyzing the displacement transducer signals with the DVF 3. All overall shaft displacement levels were obtained from the unfiltered (5 Hz - 1000 Hz) signals.

Velocity and Displacement Spectra

Velocity and displacement spectra were generated from the accelerometer signals (integrated once) and displacement signals, respectively, by performing a Fast Fourier Transform (FFT) on the digitized signal.

Bode Plots

The shaft displacement and casing velocity signals recorded during the periods of runup and rundown were analyzed using a computer managed data acquisition and analysis system developed by Mechanical Research, Ontario Hydro. Bearing housing velocity and shaft displacement magnitude and phase, at filtered 1 x shaft rotating frequency, versus shaft speed were calculated and plotted (Bode plot).

The Bode plots which show the rotor or casing response in both amplitude and phase as a function of rotor speed were used to identify rotor and structural natural frequencies.

Bode plots produced using shaft displacement transducer signals may be inaccurate if the signal from the transducer includes any appreciable amount of shaft bow or runout (ie, any deviation in the shaft surface which produces a transducer output which is not related to shaft vibration). For this reason, both uncompensated and compensated (ie, compensated for bow and runout by subtracting the slowroll vector from the displacement vector) bode plots were produced. Compensation is further discussed below.

Impact Spectra

The AC generator, power turbine, gas producer, and reduction gear box structural natural frequencies were determined by impact testing. With the unit not running, these structures were excited throughout a range of frequencies (5-500 Hz) with a hammer having an elastomeric tip and instrumented with a force transducer. The input force (hammer) and the structure's response (accelerometer signal) signals were fed simultaneously into a dual channel FFT analyzer (Ono Sokki CF 920) which calculated the input and response spectra as well as the compliance transfer function. The validity of the transfer function was checked by the coherence of the input and response signals. The ambient noise was reduced by averaging the results of eight impacts.

All impact tests were performed when the unit was cold and not running.

3.0 COMPENSATION

A Bode plot will be distorted if the signal from the displacement transducer includes any appreciable amount of shaft bow or runout (any deviation in the observed shaft surface which produces a transducer output which is not related to shaft motion). Both shaft bow and runout will create an initial vector or offset in the phase and amplitude portions of the Bode plot. As the shaft speed changes, the bow or runout value (presumably a constant) vectorially combines with true shaft motion to produce the total signal sensed by the transducer. If the bow or runout is a significant portion of the total signal, the appearance of the Bode plot can be greatly altered. These alterations or distortions may include an amplitude peak and phase shift well removed from the actual critical speed, dips in amplitude rather than peaks, or no response in extreme cases.

To circumvent this problem, the displacement transducer signal at a slow shaft speed is obtained and stored. As the shaft speed changes, the slowroll displacement signal can be subtracted from the total displacement signal to yield a signal compensated for shaft bow and runout.